Multiple Perspectives of a knowledge-based Innovation Ecosystem:

The Case of Khalifa Fund for Enterprise Development in the UAE

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ABSTRACT

This research addresses adopts the multiple perspectives theory to explore the key factors of the Innovation Ecosystems in the United Arab Emirates (UAE). It offers systemic point of view for how innovation can be transformed from an event to be a sustainable system in the country's economy to achieve the 2030 economic vision. Such fundamental transformation will rely on the knowledge-based view (adopted in this study) that the previously published research that followed the resources-based view. This view matches the countries plan to move from Oil to non-Oil economy that relies on innovation and human creativity as a key source of wealth.

Transforming the economy from the resource view to the knowledge view requires a systemic prospective that addresses the organizational, and personal perspectives beside the technical/resource view. The former two perspectives offer deep insight on cultural, institutional, and political factors that shape the design and implementation of innovation, while the later perspective demonstrate the resources available for such innovation. Linstone's Multiple Perspective Theory (1981 & 2010) synthesizing this trio perspectives and points out the ecosystem complexity and mechanisms. Accordingly, this thesis presents a knowledge-based framework of Innovation Ecosystems based on Linstone's systemic view that helps understand the UAE Start-up innovation. Using a case study of the Khalifa Fund, the study analyses UAE's innovation and ecosystem's enablers and barriers, targeting three vital sectors, including *IT/software start-ups*, *Non-carbon/Green Production*, and *life-science* sectors.

The researcher followed Charmaz's (2008) Constructivist Grounded Theory (CGT) as a design for the research process and theory building. A conceptual framework is built based on the literature review. Then, a concurrent mixed methods approach in two stages (qualitative + quantitative) have been conducted to triangulate semi-structured interviews and exploratory survey. The results of this triangulation have been contrasted against the factors included in the conceptual framework to build a final theoretical framework. The interviews targeted 21 policymakers (Government officials), Khalifa fund practitioners (top and middle Managers) and Universities Innovation consultants. In parallel, an inclusive sample of 60 surveys have been allocated to all current owners of start-ups (entrepreneurs) in the three sectors. Beforehand, an archival analysis has been conducted to develop deep narratives of the fund's activities, challenges, and overall innovation environment.

The research findings point out the multiple perspective theory as a lens to understand the meta-governance and the complexity of knowledge-based innovation ecosystem in non-oil-based gulf context. The agency principle for the UAE decision markers positions the government as a key player towards the innovation strategizing and governance. Accordingly, issues of women representation in the innovation ecosystems were present in the research findings. Issues of firm legitimacy and resource orchestration/marshalling were perceived differently between the policy makers and start-ups owners or innovators. This led to the discovery for innovation factors to be included in an advanced theoretical framework 2. This framework maps the complexity and interactivity of innovation knowledge within the institutional level (at Khalifa Fund), the international level, and the Gulf regional level. Empirical contribution is

presented for policy makers and Khalifa Fund officials on how to maintain a meta-innovation ecosystem by capturing the technological advances and facilitate the imports and legal licencing for start-ups. Organisational recommendations are also discussed in terms of enhancing innovation learning and education for current and potential entrepreneurs who aim to innovate products, services, processes, or routines. Personal recommendations are also presented for start-ups owners on how to engage with the policymakers in developing a foresight and a meta-innovation ecosystem.

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LIST OF ABBREVIATIONS

CGT	Constructivist Grounded Theory
E&I	Entrepreneurship and Innovation
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GEM	Global Entrepreneurship Monitor
HR	Human Relations
ICTs	Information and Communications Technologies
IFDI	Inward Foreign Direct Investment
IMF	International Monetary Fund
KBE	Knowledge-Based Economy
KSA	Kingdom of Saudi Arabia
KF	Khalifa Fund
MPT	Multiple Perspective Theory
NIS	National Innovation System(s)
OECD	Organisation for Economic Cooperation and Development
OFDI	Outward Foreign Direct Investment
PEST	Political, Economic, Social and Political
R&D	Research and Development
SSI	Sectoral System of Innovation
TEA	Rate of Early-Stage Entrepreneurship
TH	Triple Helix
TOP	Technical, Organisational, and Personal
TTO	Technology Transfer Officer
UAE	United Arab Emirates
UIL	University-Industry Links
VC	Venture Capital
WB/WTO	World Bank and World Trade Organisation
S&T	Science and Technology

CHAPTER ONE: RESEARCH INTRODUCTION

1.1 Research Background

Innovation in emergent technologies and associated products and services is the foundation of the world's elite group of sustainable high-income societies (Verspagen, 2005). UAE is the only Arab country to join these societies as presented in this study. According to IMF (2016), the Emirati economy has 4.5% GDP growth rate, around US$ 70,000 per capita; increasingly diversified, with a global business network, and the least corrupt. However, this economic prosperity is highly oil-dependent and therefore unsustainable. Hence, the Government has adopted Vision 2030 to build a diversified non-oil economy, (including IT/software development, life-sciences innovation, non-carbon technologies and value-adding services). This vision builds up an institutional policy that supports innovative product/service developments and enables global scalability. In doing so, social capital and knowledge are key elements for diversified economy (Westlund 2006 Ahmed and Alfaki 2016).

UAE's road to building innovation ecosystem presents a special case that is a knowledge-based than a resources-based. As Kharas (2009) and Bulman et al (2014) note those countries that have joined the group of advanced economies based upon innovation, such as Japan, Taiwan, South Korea and Singapore, have done so by avoiding the middle-income trap. This is the position were low-cost manufacturing based on technology transfer no longer offers competitive advantage yet rising wages and low levels of innovation preclude advanced economy status. Lin (2016) suggests that countries such as Thailand, Indonesia, Brasil, South Africa, Russia, Saudi Arabia, and India are in the middle-income trap. While in terms of income, UAE has already exceeded middle-income status, the challenge, as Lee and Li (2014) argue is to create competitive products from emergent technologies: shortened cycles of innovation supported by appropriate institutions (Redding 2005). UAE, following Gerschenkron (1962) seeks to leapfrog advanced economies, by creating the capability to successfully innovate in emergent technology sectors; to catch-up, overtake and join the elite group of advanced economies sustainably delivering high-incomes based upon innovation in knowledge-intensive economic sectors. With a population of only 1 million indigenous

UAE has set itself goals like those of China with a 1.4 billion population: in Winters and Yusuf's (2007, p20) phrase, to "*dance with giants"*.

Part of the literature review presents a chronological perspective of the UAE economic and cultural development towards the status of the National Innovation System (NIS) focusing on institutions that are crucial to innovation and successful implementation of the Vision 2030 (Ahmed and Alfaki, 2016). This scene-setting briefly explores UAE's economic management; its people – their education level and absorptive capacity; national champion innovation companies; financial services and their appropriateness for supporting short innovation cycles, rates of innovation and entrepreneurship, competitiveness and internationalization, social trends impacting on innovation rates and finally change drivers.

The following sections of the introduction Chapter offers a brief for the overall thesis. ***Section 1.2*** outlines the theoretical ground for this research. Linstone's (2011) multiple perspective theory and its use as a theoretical lens for understanding the innovation ecosystems and its evolution from a knowledge-based perspective. ***Section 1.3*** outlines the research aims and objectives, relating these to the research design and data gathering, and positions the research problem. ***Section 1.4*** presents and justifies the over-arching research question guiding this research and three sub-questions (what, how and why) questions. Justification of these research questions is presented further in the research gap pointed out in the literature review chapter. Parts of these questions has been answered in the literature review and later the data analysis and discussion chapters. ***Section 1.5*** argues that this research has deep theoretical significance, since it analyses a unique pathway towards an innovation-based economy for which some current theoretical frameworks are inadequate, an example being Etzkowitz's (1983) Triple Helix theory. The section argues that by featuring a case study of the Khalifa Fund, the preeminent development agency in UAE, the research has practical significance for future policymaking. ***Section 1.6*** notes gaps in previous research in relation to oil-rich, aspirant innovative societies and innovation-institution building in UAE. This section also signifies the lack of knowledge-based view of the innovation ecosystem. ***Section 1.7*** outlines the three-stage research design, based on Charmaz (2007): (a) creating an explanatory framework based on previous research and literature gaps (b) using the framework to gather data explaining reality (business cases and ecosystem overviews), then (c) theorizing (with reference to the initial framework and literature) to arrive at new theory. From this initial overview. Finally, ***Section 1.8*** gives and overview of the structure and flow of the thesis.

1.1.1. Resource-Based Economy in UAE

Al-Naqeeb (1990) identifies as an *articulated spirit* of the primacy of commerce: historically cantered on speculating trading dhows in the Arabian Gulf and trade with the interior of the Arabian Peninsula. UAE has a long history of trade, raising and using venture capital, introducing new products and state oversight of contracts and the rule of law. Now with a 1 million indigenous population, (9.2 million overall); since 1971 the seven ducal states combine under a Federal National Council: the vision of Sheikh Zayed bin Sultan Al Nahyan of Abu Dhabi and Sheikh Rashid bin Saeed Al Maktoum of Dubai.

Though discovered in 1934, oil reserves, as Davidson (2008) notes, reserves only exploited after 1971 by the National Oil Company, including refining and a terminal port. Oil revenues have been used to build a modern infrastructure exemplified by the architecture in Abu Dhabi. Currently, some 85% of GDP is oil-dependent, reserves that Ahmed and Alfaki (2016) suggest that will exhaust around 2100.

UAE's strategy to avoid the *curse of natural resources* (Sachs and Warner 2001) in the form of a *rentier state* (Auty 1985) in which endowments disincentivize entrepreneurship, is to use its oil wealth as a platform from which to diversity and join the top rank of competitive nations. This research focuses on how *Vision 2030* (2008) can be implemented and adjusted during implementation. The *Abu Dhabi Economic Vision* 2030 (2008) envisages the UAE building future GDP growth of 7% pa, a as *secure society and a dynamic open economy;* crystallizing the Expo slogan *Connecting Minds, Creating the Future* to exploit technology transfers, *the aim is for the Emirate to take its place among the most successful economies of the world by 2030*. Its strategy is to use oil reserves to fund modernisation and build an internationally successful knowledge-based economy (Al-Raisi, Amin and Tahir, 2011).

1.1.2. Government Involvement in the Resource-Based Economy

UAE is a rich country. As Ahmed and Alfaki (2016) note, GDP is US$ 0.57 trillion with a per capita GDP of US$ 69,000 per annum. It exports US$ 0.324 Trillion each year, 77% of which is oil: mainly to Iran, India, and China. Additionally, re-export is important along with natural gas, fish, and dates. Whilst 56% of employment is in industry (43% services) some 80% of overall employment is in services – the level of a developed economy (with 90% of Emeriti employment is in the public sector). Oil-related income is now 66% of GDP. UAE is the most diversified of the Gulf Consultative Council (GCC) states and the largest Arab economy after Saudi Arabia: UAE enjoys an average 4.5% GDP growth rate. According to international indices (IMF 2016) UAE is one of the top-twenty countries to "do business," is highly networked and amongst the least corrupt. According to the IMF (2016) UAE is already the most *economically complex* of Arab oil states, evidenced by its export diversity and (for example a TEA-rate of 12 new businesses per 1,000 of population per year [early-stage technology entrepreneurship]).

Outward foreign direct investment (OFDI) is US$ 3 billion and inward foreign direct investment (IFDI) some US$ 10 billion. The *Emirates* brand is internationally recognized as an airline, football, retail, property development and financial services. OFDI is mainly by state owned enterprises (SOEs) and managed by Abu Dhabi Investment Council, Emmar Development Company, International Petroleum Investment Company, Dubai World and Dubai International Capital.

The IMF (2016) sets out a Washington Consensus model (based on North 1990; Chaudhry 1994) for UAE and Gulf countries' diversification, including low taxes, small state expenditure and open markets. Plainly, the UAE Government strategy rejects oil-dependency and the rentier state model (Beblawi 1987). An underpinning question in this research is the extent to which the IMF model is one-best-way, if or alternatively a UAE innovation-based knowledge economy innovation model is possible. For UAE citizens, retaining the Islamic structures and culture is of fundamental importance; many adopt the slogan *modernization without westernization*. This research addresses later the issue of whether alternative transition routes from the rentier state (and Beblawi [1990] *rentier mentality*) are possible; here noting debates on alternatives can be found in the work of Bulte et al (2005), Losman (2010), Field (1984) and Auty (2004), and the suggestions that resource-richness disincentivizes entrepreneurship (Sachs 2001; Auty 1997, 2001) and creates instability (Collier, 2008).

1.1.3. Education and Knowledge for Labour Market in UAE

Learning and education have always been esteemed in the Arab traditions (Robinson 1996; Aslan, 2011, Alkhateeb, 2014, Lapidus, 2012), perhaps particularly in the Arab world. With literacy above 95%, a well-funded K-12 programme currently serves the 650,000 school pupils in UAE providing universal compulsory education that meets international standards. The Programme for International Student Assessment (PISA) scores math's at 453 in UAE; in the bottom third illustrating challenges ahead, reflected in only 13% of graduates taking science degrees.

Free university education enjoys high enrolment rates (95% female and 80% male) and freely available scholarships for further and international study. Degree-level study in UAE is expanding rapidly in its seventy-one institutions covering universities and the Higher College of Technology. There are also 86 adult life-long learning centres. Universities in the world top-400 include UAE University, Zayed University, Khalifa University, American University of Sharjah, and University of Sharjah. Many are co-educational. International campuses (Herriot-Watt, Sorbonne, NY University) are popular (Kirk and Napier, 2009).

The nature and socio-economic contribution of universities is sharply debated (Gibbons et al, 1994), no less so in a developing economy context where individual education and returns to education balance against economic (labour market) needs (Wolf 2002; Stevens 1990; Yamada, 2000). Melley (2010) suggests the need for more vocational education in UAE. Studies such as Gaspar and Glaeser (1998) and Kim (2000) emphasize the role of universities as providers of skilled labour in developing countries. While vocational education is important, UAE's vision also anticipates a key role for universities undertaking basic research and its commercialization into competitive new products. As Pavitt (1998) and Spinouts UK (2012) point out, without basic research the absorptive capacity to conduct developmental or applied research is reduced. Kirk and Napier's (2009) study of UAE universities conclude that a mix of investment in outward international study alongside international faculty recruitment is UAE's best route to basic research. However, they note that the current ratio of one-third international faculty remains low by top international standards and some of those recruited are no longer research active. Austin et al (2014) argues that adaptation to local culture, whilst commendable has led to many western lecturers abandoning critical pedagogy and complying with grade-inflation pressures.

The UAE Government policy of *Emiratization* of universities is a long-term strategy, reliant upon perhaps a decade of sending students abroad and a clear focus research centres capable of commercialization. This research returns later to the valuable experiences in Japan, South Korea, Taiwan and now China in adopting problem-centred research in alliance with major companies and international universities, paralleling UAE's development. Innovation capacity takes time to build. For example, the Knowledge Integration Community (KIC) model (for example between Cambridge [UK] and US's MIT) are based as Acworth (2008) found on a 'thick' institutional heritage of both companies and universities with advanced technologies and research capabilities (Owen-Smith 2002; Howells 2006).

Basic research's economic impact is reliant upon close university-industry linkages (UILs) and successful incubation centres - as numerous researchers have shown including Liefner and Hobday (2000), Lall (2000) and Schiller (2008). UAE currently has research centres in space science (exampled by the proposed Mars expedition), health sciences, Genetic Engineering and Biotechnology, Traffic Safety, Public Policy and Leadership, Water Technical and a Date Palm Research Unit. Incubation facilities are still emerging, offering a wider range of services (research, business services, training, innovation showcases, commercialization and business consultants) but without the business (rather than academic) leadership, close business mentoring and time discipline found at leading commercialization universities such as Stanford, MIT and Cambridge (Goldstein et al, 2012). According to Hameed et al (2016) only 3% of UAE start-ups have advance technology products, from which they conclude that more entrepreneurship education in universities is necessary. While important, market success, including for example financial service products with low advanced technology, are also important.

This research also investigates issues associated with intellectual property (IP). *The Economist* (2002) stated that the Bayh-Dole Act was the most distinctive piece of law in the US in the second half of the 20th century making it easier for universities to retain IPR from academic research by filing patents. While the UAE has a clear legal framework for IP, it is not clear how universities and SMEs are applying the system, a point covered in empirical work in this research.

These strengths and weaknesses in the university system and commercialization are crucial points to which this research returns later in particular the challenge of joining international research and development (R&D) networks and attracting R&D activity by international companies in addition to improving indigenous R&D output.

An innovation-based ecosystem presumes people capable of creating innovations: a rich reservoir of talented people. For this to occur, UAE is improving its education and research systems. Improving the knowledge capital of people and the rate at which original research is migrated into commercial products, will be shown to be a key building block in an innovation ecosystem.

In summary, studies over-time including Fasano and Iqbal (2003), Davidson (2011) and Hertog (2010) argue that human resource and labour market reform is central to diversification in UAE, and includes lowering dependency on migrant, increasing women's participation rate and shifting Emiratis from public sector into high-value private sector employment. Hanieh (2011) notes that unless this occurs the ability of the state to create stability will be threatened by declining oil revenues, underlining the importance of this research work.

1.1.4. Innovation and Economic Growth in UAE

Listings of the top Gulf companies (by turnover and profit) such as Gulf News (2017) find that UAE has a similar number of top-twenty companies as Saudi Arabia. UAE's major companies include Emirates Airlines, which has a US$ 22 billion turnover and Etihad Airways is important in airline services and logistics. Companies such as this indicate the development direction of travel UAE hopes to take. As figure 1.1 illustrates, globalization has enabled many countries to achieve mid-income status, however Kuznets (1955) point out that it is the transition from mid to high-income that is most difficult because it relies not on transferring technologies from developed economies. Instead, this second transition requires and educated workforces capable of supporting internationally competitive companies with products develop (in this case) in the UAE.

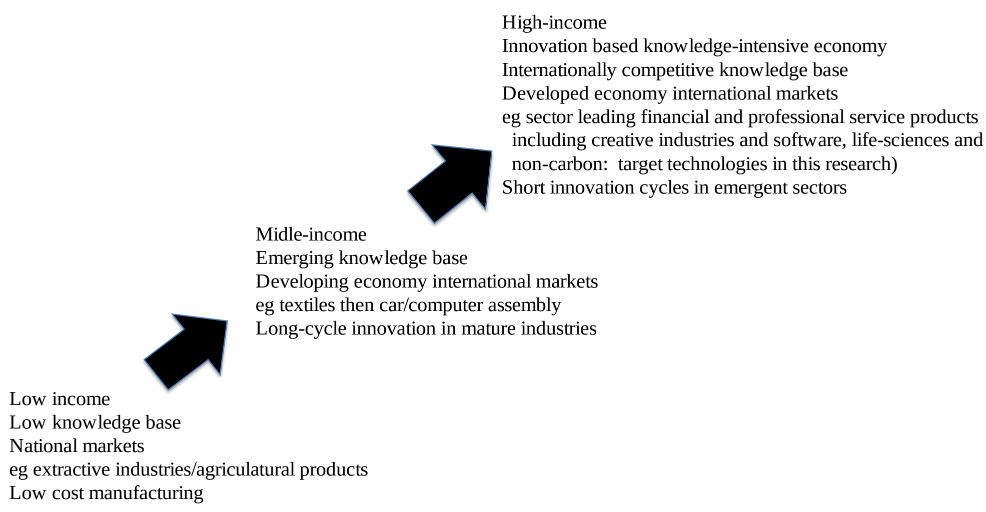


Figure 1.1: Transition points in development
(Adapted from Kuznets 1955 and Lee 2014)

Other successful companies in financial services include Abu Dhabi's First Bank (US$ 17 billion capitalization), Emirates NBD, Dubai Islamic Bank, Commercial Bank of Dubai, Abu Dhabi Islamic Bank, the Abu Dhabi Commercial Bank and Tamweel. Some such as Aldar Properties, Emaar properties and DAMAC Properties specialize in property development. Hotels are important in UAE given the rise of tourism with Abu Dhabi National Hotels, Emaar Properties, Nakheel Properties and Emaar Malls Group. UAE's oil sector includes the Abu Dhabi National Energy Company (TAQA), Abu Dhabi National Oil Company (ADNOC). In the gas sector, the Dana Gas Company.

Outside of the well-known successful sectors, a high level of diversification is apparent. UAE's logistics companies include Dubai Ports (DP) World with a US$ 16 billion capitalization, and Abu Dhabi Ports Company. The growing software sector includes Alpha Data, ITQAN and a wide range of software solutions companies, some with joint ventures in the US and/or Bangalore. Media companies include Abu Dhabi Media Company, Dubai Media Incorporated. Telecommunication companies include (Etisalat) Emirates Telecommunication Group (US$ 34 billion turnover), (du) Emirates Integrated

Telecommunications Company and Thuraya and numerous companies in Dubai Media City. The industrial sector remains vibrant with companies such as Liwa Chemicals, Julphar Pharmaceuticals and Unibeton Ready Mix. Additionally, a few new state-owned enterprises (SOEs) are flourishing such as State aerospace organization.

Turning to the small-to-medium sized enterprise (SME) sector, the (Global Entrepreneurship Monitor (GEM, 2013) report finds 200,000 SMEs in UAE vindicating Taatila's (2000) argument on their importance for the region. GEM notes the high start-up rate and that in Dubai they employ 42% of the workforce and constitute 72% of all businesses. However, closer inspection (Dubai SME 2013) reveals that a high proportion of SMEs are foreign owned (particularly limited liability companies, by Indian migrants), the three-year failure rate is 50%, and are mainly in trading (57%), contracting and healthcare sectors (35%) – i.e. sectors difficult to internationalize. Indeed, few SMEs are innovative and knowledge-based (with readily exportable products) meaning that few enjoy the 'gazelle' (rapid) growth necessary to attract the international initial public offering (IPO) of shares to the public i.e. capital necessary to internationalize. This picture links closely to the comments above on low university commercialization rates of high-tech products. Whilst 51% export, their exports are usually service payments or re-export of traded goods.

Since Porter (1990) researchers have pointed to the importance of knowledge-based clustering as a stimulant for innovative products, in particular clustering around universities active in basic applied research (Agrawal and Henderson 2002) with close industry linkages, since as Looy et al (2005) argue, patenting and publishing ought not to be alternatives. UAE R&D spend is low at 0.7% GDP relative to the 2% OECD average, though the figure is low because oil-related GDP is so high.

Takamul launched under the auspices of the Government's Technology Development Committee aims to increase the rate of international patenting using the GCC patenting office in Riyadh. Of 1,368 applications in 2016 (Gulf News 2016) 185 were granted, subject to international appeal. How many of these embed software, non-carbon and life-science will be revealed in some of my quantitative work.

In summary, UAE appears to have successfully begun the process of diversification, however future success relies upon indigenous knowledge creation and its exploitation by indigenous companies. In the software, life-science and non-carbon sectors this research will comment on the issues this section has shown face SME start-up and growth in sizeable companies.

1.1.4.1 Financing Start-Ups

UAE bank assets are 150% of GDP and it enjoys the highest financial services penetration of all GCC countries, including use of foreign banks operating in its open regulatory environment and private sector (the UAE Government has minority holdings in half the local banks) bank ownership and range of investment funds (WB 2015). Half of the 46 commercial banks are indigenously owned, and licensing arrangements control foreign bank entry and prescribe joint venturing. The stock market capitalization is 18% GDP, bank deposits 68% and insurance widespread (often B2B in logistics).[1] Both the Dubai International Financial Centre and Abu Dhabi Global Market attract significant international activity often seeking corporate finance. With a 19% ratio of capital to risk-weighted assets, UAE banks easily comply with Basel III safety ratios (WB 2016). The Government sponsored Khalifa Fund (KF) supports SMEs by direct lending and capped credit guarantees. Given its large migrant population, outward remittances are a major financial service in UAE at US$ 19 billion the largest in the world (Gulf News 030517).

For SMEs the financial system is dysfunctional. IMF (2015) suggests that banks reject 70% of SMEs credit applications and that the institutional framework to support SMEs remains under-developed, in particular lending against future income streams rather than current (physical) assets. Public interventions such as the Khalifa Fund (Report 2016) are important: since establishment in 2007 it has financed 317 projects (77% male, 69% Abu Dhabi located and 58% service products). The Mohammed Bin Rashid Fund for SME makes a similar contribution.

In B2C and large business B2B UAE’s financial services sector is successful, however, this is less so in relation to SMEs, a point featuring prominently in this research on the innovation ecosystem.

[1] Using the now conventional business to business (B2B), business to customer (B2C) shorthand.

1.1.4.2 Innovation & SMEs in knowledge-based sectors

GEM (2016) places total early-stage entrepreneurial activity (TEA) for UAE as equivalent to Singapore and Norway. Though lower than innovation-driven economies (US, Netherlands) this is a major achievement. While there remains a preference for 'safe' employment in the public sector or major banks as Al-Waqfi and Forstenlechner (2012) note, Goby and Erogul (2011) and Erogul (2014) argue that these are declining preferences amongst young people.

As Gundala and Khawaja (2014) note, UAE's 72,000 SMEs in 2014 were responsible for 80% of private sector employment, 40% of all employment and 60% of GDP: they constitute, Kumar (2014) notes, 95% of all UAE enterprises, resulting as Elmansori (2014) details a high standard of living and low tax economy.

Successful entrepreneurs (honoured by the Asia Pacific Entrepreneurship Awards in 2016) include the Chair of Al Maskari Holdings (a social innovator), Managing Director of BB Energy (creator or an integrated energy trading company) and the CEO of Paramount Computer Systems (innovators in cyber-security). As Hertog (2010) show, Asian economy manufactures exports are 30% high-tech whereas the figure for UAE is 3.2%, illustrating the level of opportunities facing UAE's manufacturing sector and its SMEs.

For knowledge-based innovative new businesses, educated young people are especially important and in UAE's case young women (Doumato 1999). Exploring the links between innovation, entrepreneurship and education in UAE Sowmya et al (2010) note the high percentage of women in UAE's HE (60%), with 80% of these being first generation higher education (HE) graduates. From a low base, women's employment participation has risen from 2.3% in 1975, to 22% in 2006 and is now 40% (WB 2016). Sowmya et al (2016) find that 70% of young women want to start their own business, against 60% in an international sample, with 82% having a business idea compared to 70% in the international sample. These findings contradict Majumdar and Varadarajan (2012) who found a lack of entrepreneurial culture amongst the Emiratis generally. However, focusing on young people in HE reveals a different story since as Iglesias-

Sánchez et al ’s (2016) research reveals being at university promotes entrepreneurship. This is especially so, Solesvik et al (2014) suggest amongst UAE students exposed to entrepreneurship education, which Ashour (2016) recommends is extended throughout UAE’s 86 higher education institutions. Nonetheless, Ryan *et al* (2011) find UAE higher education students characterized by self-motivation and a need to achieve. Motivations, both pull and push young Emirati women to becoming entrepreneurs, Tlaiss (2015) finds, suggesting they are becoming a major source of innovative new company development. Studies such as Jabeen et al (2016) recommend more HE more links to business, incubation, active learning of entrepreneurship; these to which my research will later return.

In summary, entrepreneurship is well established in UAE, strengthening the diversification strategy, though a detailed picture of support mechanisms (IP, risk capital, exit routes) is needed. The outlook for young entrepreneurs, a university spinout companies, and young women entrepreneur is less clear: gaps that this research addresses.

1.1.4.3 Innovation & Competitiveness in the UAE

UAE ranks 12th in the World Economic Forum’s Global Competitiveness Index, a similar position to the UK and higher than Norway and Denmark, with growth in education being the crucial area for movement up the index. Key factors include access to finance, zero direct taxation and open, transport infrastructure and reliable markets. Not often considered is the intense competition between Emirates to attract investment. UAE’s competitiveness has resulted in the tallest building (Burj Khalifa in Dubai), largest man-made port (Jebel Ali) and the largest mall (Dubai Mall with 1,200 stores).

As Al-Ansari *et al* (2014) has shown, individual UAE firms are capable of successfully adopting modern managerial techniques to improve competitiveness, perhaps more impressive is the creation of new sectoral systems of innovation, for example in solar energy generation (Vidican *et al* 2016). An important aspect of *Vision 2030* is raising competitiveness, emulating the solar example in other sectors including the software, non-carbon economy and life science sectors upon which my research focuses.

In 2015, UAE exported US$ 147 billion (30th largest in world) and imported US$ 217 billion (19th largest), resulting in a negative trade balance of US$ 70 billion. Trade with China is a good indicator of internationalisation. Since 1984, UAE and China have signed 36 agreements (Jamestown 2017) including UAE membership of AIIB and a US$5 billion currency swap to encourage trade. Technologically, Sheikh Mohammed bin Rashid Al Maktoum's (Vice President of the UAE) *Dubai Clean Energy Strategy 2050*, focuses on solar generation with *Shurooq* (the Sharjah Investment and Development Authority) negotiating with Chinese constructors according to Thaidian (2017). This *lean, clean and green* vision has attracted many of the 2,000 Chinese firms currently operating in UAE. The country can then claim success in internationalization and a competitive edge in some emerging sectors such as non-carbon technologies and value-adding financial services.

1.1.4.4 Innovation & UAE Business Culture

It has long been understood that cities are cauldrons of innovation: ideas readily communicate, the market for new products large and sophisticated, and a culture of innovation thrives as an increasing division of labour gives rise to new services (Castells and Hall 1994). Sassen's (2006) study of globally successful cities makes the point that value adding services (lawyers, accountants, marketing and design agencies) cluster around large companies in cities. This is in addition to the cultural industry businesses requiring the large base of a city. UAE's largest cities are relatively small. Implementing the *2030 Vision* means attracting and creating internationally mobile innovators and scientists. This research explores in detail how this can be done and in particular the challenges of building the first global hub in the Gulf area.

For many developing economies, (China is an example) the challenge is to move from a low-cost, export-driven manufacturing base giving middle-level incomes, towards a fuller developed economy characterised by competitive knowledge-embodying products (mainly services); the development model found in Mokyr (1990), North (1990) and Landes (1998). This is not the case for UAE, which already has elevated levels of per capita income, albeit based on the unsustainable income from a natural resource.

Emiratis enjoy a good life yet know that since oil-dependency is unsustainable the Government's *2030 Vision* offers a way of sustainably joining the world's elite developed countries – the first Gulf or Arab country to do so. The UAE Government aims are *for the Emirate to take its place among the most successful economies of the world by 2030*. Institutional change and leadership are critical to the accomplishment of this vision. Table 1.1 summarizes the achievements of the UAE and the challenges now facing its next phase of development.

UAE context	Items for investigation in my research
Oil-dependency as disincentive to entrepreneurship and innovation	• Search previous research in literature review • Investigate the KF and the motivation of entrepreneurs in a case study of the Fund • Include question in four sets of interviews
Government economic management strategy 2030 Vision as transition route from rentier state	• Carefully and critically consider debates in literature review • Benchmark UAE data (using GEM, IMF) against resource-rich and non-resource rich economies
Education system role in ecosystem for innovation and entrepreneurship	• Careful evaluation of literature on the creation of future knowledge workers in review chapters • Questions in business survey • Questions in four interviews on effectiveness of university commercialisation processes and entrepreneurship education • Clarify and evaluation IP and exit-route standards and processes against best practice benchmarks
HR and labour market issues	• Carefully draw causal relations from previous research and include them in the new framework • Include set of questions for policy interviews
UAE companies	• Benchmark data from new survey with data from best practice benchmarks for software, life-science and non-carbon sectors • Benchmark international GEM data against UAE • Include clustering questions for interviews
Financial services	• Include SME raising of capital in the new framework • Benchmark risk capital, bank facilities and exit routes for SME against international best practice • Include questions in survey to establish current SME experience in UAE
Innovation and entrepreneurship	• Benchmark survey results against international best practice such as GEM and IMF studies • To cross-reference international standards against UAE achievements
Competitiveness	• Clarify qualitative and quantitative metrics of success in the new framework
Culture	• Carefully construct causal links in new framework drawing from literature and my data analysis and include these and in the second version of my framework

Table 1.1: Issues impacting on my research from discussion on UAE context

In the next two chapters this research critically considers previous research on innovation and entrepreneurial ecosystems building up to creating a framework in chapter-3 with which to analyse the current situation and future perspective for UAE's economy; in particular the implementation of the *2030 Vision*.

As an Emeriti contributing to the future of the country is important, also important is the intellectual motivation for this research work, to which this chapter now turns.

1.2 Multiple Perspectives of Innovation

Harold Linstone, the founding-Editor of *Technological Forecasting & Social Change* and originator of the multiple perspective theory for decision-making, inspired this work and the research approach. As Linstone (2009) records, the multiple perspective has its origins in wartime operations research techniques, giving rise to and the work of Allison (1971) and Churchman (1971) on decision-making, who's work also informed Kahneman and Tversky's (1979) *prospect theory* and later general systems theory (Von Bertalanffy 1981; Checkland 1981). Linstone's work is now the dominant approach to forecasting research. This section briefly indicates how his thinking evolved and why it inspires this research on migrating the UAE into an internationally competitive knowledge-based innovation ecosystem. In the literature review below, we explore how researchers have developed Linstone's approach including Bigliardi *et al* (2015), Kim (2017), Strasser (2018), and De Valerio *et al* (2020)

Linstone (1981) and (2010) clarify the foundations of the multiple perspectives theory as an extension for the socio-technical school of thoughts (Trist 1981) and as systemic lens for the technical (**T**) organizational (**O**), and personal (**P**) epistemological stances of the stakeholders' perceptions while encountering the knowledge-based Innovation Ecosystem. Linstone's approach helps building a problem-cantered mechanism that the researcher found suitable to understand the UAE economic migration towards non-Oil Based Economy. This systemic theory helped proposing key themes for building data collection instruments and selection of data coding techniques. This systemic lens helped the researcher to avoid over-simplification of the research phenomenon into a deducted model of sub-systems and to be wary of early closure on ontological or epistemological choices likely to exclude relevant knowledge. Although Linstone insists upon a robust evidence base for situational and forecasting analyses, he views a rush to quantification as problematic since in it diminishes nuances arising from cultural and contextual differences. This latter point is especially important to emergent research on UAE, since as will be argued, little research has been conducted and these factors are therefore of unknown importance. Along with later researchers, such as Rosenberg (1982) and Rosenberg and Birdzell (1986), Linstone argues that presumed linearity introduces determinism into technology analysis and in particular understates the important role of agency, especially of entrepreneurs. For Linstone, time frame and unit of analysis important influence analysis results: an important consideration for this UAE research given its dynamic nature, particularly as institutions emerge.

As he developed the idea of multiple perspectives, Linstone (1981) refined the idea of technical, operation and personal (TOP) categories interacting in decision-making, an idea Gibbons *et al* (1994) would later term trans-disciplinary knowledge. The TOP approach frames a holistic system in which pragmatic factors (each with a weighting) interact: many researchers now term this scenario planning and as we show below technology road-mapping (De Valerio *et al* (2020). However, for Linstone (1981 and 2010a) method is more sophisticated that ascribing probabilities to factors. Pioneering the use of Delphic Panels developed by the RAND Corporation, Linstone is wary of bias from the observer-research, who necessarily comes with biases. Trans-disciplinary immersion by the leading researchers and iteration with experts aims to ensure the validity of conclusions and their limitations in terms of risk (for which perceptions vary) and generalizability (between cultures and contexts. For Linstone, the multiple perspectives approach is applicable to a wide range of socio-economic issues, in addition to technological forecasting.

As his thinking developed, Linstone (1988) placed greater emphasis on openness, rejecting the idea that consensus or optimal solutions are necessarily the best. In this he inspires me to take reflective (triangulation) approach to my UAE research, giving careful weight to both qualitative and quantitative data. Stressing that any problem and be view from any angle, Linstone intends the multiple perspective approach to imitate a Socratic method: constantly inquiring, expansively challenging provisional conclusions and looking deeply at system causal relations and boundaries. He draws attention (1996) to the gap between social institutions and attitudes and technological capability - *mismatch theory* – pertinent to the UAE case, where, as will be argued, simple technology transfer has failed to create anticipated knowledge spills raising the issues of commercialisation and TOPS in Galati *et al* (2016) considered below. Instead, Linstone strives to envision inter-dependent ecosystems as mutually interacting learning systems in which technologies are always adapted to context and culture, without which (as Solow 1956 argued) mismatches amplify. Like Linstone's (1999) work, the framework developed here will have practical use in guiding policymakers and entrepreneurs.

In his later work, Linstone (2009) returns to some basic systems arguments emphasizing rising system complexity coupled to multiple causation and unintended consequences: in short, people are unpredictable and while all modelling fails to capture reality, sensitive modelling usefully guides decisions. As is necessary in my research, Linstone criticizes short-termism (*discounting the future*) stressing the opportunities and dangers of online collaborative knowledge structures (2010). His (2011a) critique of some scenario planning exercises, gives important lesson for my research drawing attention to molecular ecosystems as a metaphor and the importance of reiteration with experts in exploratory research. As we show below, Kim (2017) too refocuses TOPs towards a whole network perspective. Additionally, in (2011), citing the successful Japanese Technology Foresight and Allison's work, he urges multiple perspective researchers not to lose touch with normative forecasting: in the UAE's case, this is especially important given the determined leadership of the Government to achieve its knowledge-economy goals: creativity and credibility in research conclusions, Linstone (2011) argues are not mutually exclusive.

Here, the methods chapter will explore some of the critiques of Linstone's work, look in more detail at his work in Japan (1994) and Zhichang's (2010) work on theorizing systems methodologies across cultures. For the moment, this work notes the intellection inspiration for my research of Linstone's contribution.

1.3. Research Aim & Objectives

This research aims to develop a theoretical and empirical understanding of the knowledge-based innovation ecosystem as an essential mechanism towards non-oil economy in the UAE. It also examines if the Multiple Perspective Theory (Linstone 1988; Linstone, 2011) can help developing this understanding in a systemic fashion. The following objectives will be fulfilled by the end of my PhD journey.

Objective 1: *Review the relevant innovation systems literature and develop a conceptual model that helps mapping of the key factors constituting knowledge-based innovation ecosystems.* To achieve this objective, journal articles included in this review are downloaded from 2*, 3*, and 4* ABS journals such as Research Policy, Technological Forecasting and Social Change Journal, Journal of Creativity and Innovation Management and Journal of Innovation: Management, Policy and Practice. The review informed the development of a conceptual model that includes the macro-level factors and stakeholder mapping of the innovation ecosystem. It also includes meso and micro-level factors and tracks the technical and personal factors included in the innovation processes.

Following Nicholson *et al* (2018) we reflect at the end of each section and at the end of each chapter on the conclusion drawn, as Nicolson *et al* note contributions may be incremental (adding to empirical data or meanings), revelatory (addressing gaps in the literature), replicatory of previous studies, consolidating existing knowledge in the field or creating a new conceptual framework. Since this is PhD research the latter is our aim: to make a publishable new contribution to theory. Our research strategy, following Charmaz (2019) accomplishes this aim by creating a first analytical framework (Chapter-3) based on the literature review (Chapter-2) and then a revised framework (Chapter-7) based on the new data (Chapters-5 and 6). This theory is not what Llewelyn (2002) terms context-free' 'grand theory and instead a new conceptual framework tightly relating to the context and culture of UAE and it multiple levels and perspectives (Linstone 2009).

Objective 2: *Theorizing if found, a knowledge-based innovation ecosystem and to develop a systemic understanding of its complexity.* To achieve this objective, the researcher has critically reviewed the relevant theories of innovation systems that help understand the complexity of the knowledge-based ecosystem. Alternative theories such as National Innovation Systems, Triple Helix, and absorptive capacity have been reviewed in terms of their suitability for achieving the research aim and answering the research questions. Then, the choice of Linstone's Multiple Perspective Theory is, then, justified concerning the research aim, questions, and the nature of the emerging knowledge-based innovation ecosystem in the Gulf context, showing also how the MPT approach readily aligns with complexity theory such as Arthurs (2015).

Objective 3: *Demonstrating the epistemological instance for constructive grounded theory and justifying the major methodological choices and their relevance to the research aim and questions.* A materialist ontology and epistemic approach is following (Ilyenkov 2020) focuses on human activity and decision-making. The research blends qualitative interviews and qualitative survey data collection methods are demonstrated and justified in Chapter 4 including Charmaz's (2008) theory. While mixing methods, the main method in this research is qualitative. Both methods have been followed in parallel than in sequence, but the researcher had to write them in sequentially to demonstrate the findings and the triangulation process. The interview and survey data have been used to build a theory of knowledge-based innovation ecosystem tailored to Gulf context. The interviews targeted 21 policymakers (Government officials), Khalifa fund practitioners (top and middle Managers) and Universities Innovation consultants. In parallel, 27 surveys have been allocated to the owners of start-ups (entrepreneurs) in the three aforementioned sectors. Beforehand, an archival analysis has been conducted to develop deep narratives of the fund's activities, challenges, and overall innovation environment. These two paralleled data collection journeys have led to a systemic guideline for policymakers and SMEs in UAE (and other Gulf countries). Such a guide can be used to strengthen their contribution for the knowledge-based innovation ecosystem. The final framework provided in this thesis contributes to Nonaka and Takeuchi's (1995) view of innovation as a mix of codified and informal knowledge that circulates among a network of risk-taking people. Considerations for both formal and informal knowledge have been demonstrated in this thesis.

Objective 4: *To offer a deep understanding of the cultural and contextual factors that enhances the innovation ecosystem in the UAE.* To achieve this objective, the researcher used Skok and Tahir (2010) to build an operationalized model of the innovation ecosystems. In doing so, detailed understanding of how they factors are evaluated is presented at the end of this research.

1.4. Research Questions

A research problem is what Granovetter (1985) and later Lapsley and Llewellyn (1995) term a real-life construct; this research seeks to elicit contextual rationalities from embedded and changing social practice. They recommend that such exploratory research adopts the approach of asking what, how and why questions; for which data is then gathered and interpreted by triangulating between existing theorizations and newly developed (what Llewellyn 2006 terms) intermediate theory.

The researcher decided to create three research questions (what, how and why) ensuring that each referred to a gap in the literature, was a significant question to ask.

Inspired by Linstone (2009) adopting a multiple perspective on complex and seemingly intractable socio-economic issues, with one over-arching research question and three subsidiary questions, as shown below.

RQ: To what extent does Linstone's Multiple Perspective Theory help understand the foundations of the innovation ecosystem in the UAE?

Sub-RQ1: What are the key factors of the knowledge-based innovation ecosystem in the UAE?

Sub-RQ2: How policymakers and entrepreneurs perceive that the challenges facing the innovation ecosystem in the UAE?

Sub-RQ3: How the knowledge-based innovation ecosystem operates at the meta level in the UAE?

1.4.1. Main Research Question:

RQ: To what extent does Linstone's (2009) Multiple Perspective Theory help understand the foundations of the innovation and entrepreneurship ecosystem in the UAE?

This key research question led to the adoption of Linstone's (2009) multiple perspectives theory (including his idea of the technical, organizational, and personal perspectives) to build a theoretical framework. The researcher used the *technical* perspective to address the *technology-related knowledge of innovation*, the *operational* perspective to address the *organizational issues*, and the *personal* perspective *political and self-orientated issues in the innovation knowledge* (See the research framework in Chapters 3, 7 & 8). This new framework applies Linstone's work to the innovation ecosystem in the UAE context. The researcher also grounded his theoretical development in Dewey's pragmatic technology (Hickman 1992) to understand the emerging context of innovation in the UAE and built boundaries and causalities to analyse the transition from oil-dependency to a KBE, taking the UAE's Khalifa Fund as a case study. Answering this research question will help filling the theoretical gap of lack of theorization for the innovation ecosystem and lack of use for the multiple perspective theory in the area of innovation. It also offers an insight on the innovation ecosystem for a transitional non-oil-based economy in the Middle East and Gulf context.

1.4.2. Sub Research Questions

Sub-RQ1: ***What are the key foundations and aspects of the innovation ecosystem in the UAE?***

This sub-question explores the key factors that shape the innovation ecosystem in UAE in practice, beginning by contrasting with how previous researchers and policy statements portray the ecosystem as working. The initial framework presented in Chapter 2 demonstrate these factors in different layers from the inside-out. These factors represent the foundation of the ecosystem, including resources, processes, innovation agent.

Sub-RQ2: ***How policymakers and entrepreneurs perceive that the challenges facing the innovation ecosystem in the UAE?***

This sub-question addresses how the foundations of innovation ecosystem interact in a mechanism to shape the so-called knowledge-based innovation ecosystem. Answering this question draws from interpreting the participants personal and emotionally charged decision-taking process when developing innovative products, services, and processes, in the proposed case of Khalifa Fund. The answer for this sub-question is provided in Chapter 5 & 6 where the policy makers and entrepreneurs (start-up owners) expressed their perceptions for the challenges facing the innovation ecosystem and reflect the trio perspectives of Linstone's theory. This sub-question delves into roles and relationships, beyond structures and policies. Personal, family and business networks will support gaining deep access to UAE entrepreneurs exploring the cultural and emotion grounds for their key strategic decisions making the question answerable by constructing an elite sample.

Having identified the strengths and weaknesses of UAE's E&I ecosystem in RQ1, this question uses data from policymakers and university, incubation and fund managers to explore within the new framework, how challenges are being met at the moment. How are do key agents frame problems/issues facing UAE's innovation ecosystem.

Sub-RQ3: *How the knowledge-based innovation ecosystem operates at the meta level in the UAE?*

The final framework presented in the discussion chapter offers a theory (or a systemic insight) of Khalifa fund's proposed innovation ecosystem. This framework can help critically evaluate the effectiveness of this knowledge-based approach and suggest a plan of actions to improve the UAE's innovation ecosystem. It also offers a meta level as well as a firm-level insight of the innovation knowledge and the relationships between innovators, policy makers, innovation agencies and other stakeholders.

Given that the researcher is a staff member at Khalifa Fund for Enterprise he managed to interview high-level Government officers, policy makers and business networks. Such involvement helped the researcher to access the star-ups/entrepreneurs repository list to conduct his survey complete the design and two units of analysis in his case study of Khalifa fund for enterprise.

Table 1.2 summarizes the inter-relationship between the research questions and the gaps in the literature to which they relate and then the data that brought to bear in answering the research questions.

One important consideration in selecting these research questions is the socio-technical nature of innovation ecosystems. Unlike purely technical systems, as Lewin et al (1999) and Anderson (1990) insist innovation ecosystem dynamically interact with their social environment (meaning markets, entrepreneurship enablers/barriers and regulatory constraints. Lewin's' term 'nested' is used to convey this dynamic inter-relationship.
As Archer (2003) points out there are two implications of this perspective: firstly, it is assumed that innovators and entrepreneurs have active agency – they enjoy choices,

which while influenced by the institutional environment are not determined by the environment; and secondly, patterns of innovator choices over time, evolve and alter the institutional environment (e.g. by changing regulations or legitimate actions. The research questions are then nested: research moves freely between individual innovators situated in firms, also situated in innovation sectoral systems and situated in the UAE's national economy. In this way the research questions fully include the environment in which innovators and entrepreneurs operate: the culture and context relevant to successful innovation in my three chose sectors.

A further decision in selecting these research questions is not to undertake a comparative study. The focus here is on UAE innovators: a comparative study involves a lengthy analysis of another culture and context, this approach cites best practice in advanced innovation systems while avoiding distracting focus from practice and possibilities in the UAE. In making this choice, the research follows the advice of numerous methods theorists, including Bryant and Charmaz (2007), to restrict the number of factors in the research to the minimum needed to answer the research questions. This choice fits closely with Linstone's (2010) multiple perspective approach, delimiting the multiplicity of perspectives chosen to those relevant to the research outcome.

Question	Literature gaps	Data	Method	Presentation	Analysis
RQ: ***To what extent does Linstone's Multiple Perspective Theory help understand the foundations of the innovation and entrepreneurship ecosystem in the UAE?***	• Applicability of ecosystem theory to emerging and Gulf	• Linstone and others applying MPT empirically	• Desk research and systematic literature search	• Critical review of existing frameworks	• Presentation and justification of new framework in Chapter-8
Sub-RQ1: ***What are the key foundations and aspects of the innovation ecosystem in the UAE?***	• Absence of research on UAE innovation ecosystem	• Reports: UAE, WB, IMF, GEM • Survey of 27 companies • Background from expert interviewees	• Self-completed questionnaire • Quantitative analysis	• Background • Data chapters-6	• correlation • Descriptive statistics
Sub-RQ2: ***How policymakers and entrepreneurs perceive that the challenges facing the innovation ecosystem in the UAE?***	• Technical, operation and personal roles and relationships in a Gulf culture and context	• Interviews with 21 policy makers • Study of UAE innovation ecosystem	• Qualitative • Semi-structured interviews	• Case study of Khalifa Fund and its context	• Thematic and narrative analysis
Sub-RQ3: ***How the knowledge-based innovation ecosystem operates at the meta level in the UAE?***	• Ecosystem framework useful in Gulf innovation ecosystems	• Policymaker interviews	• Mixed method	• Chapter-2 on Literature review	• Triangulation with literature • Meta-analysis of context and culture of innovation ecosystem

Table 1.2: Summary of research questions, literature, data and analysis techniques

1.5. Research significance

This research has significance by (a) filling empirical gaps, (b) adding to knowledge of innovation and entrepreneurship theory by applying Linstone's (2009) Multiple Perspective Theory to a Gulf innovation system and considering its implications for a resource rich environment and (c) providing a new analytical framework to guide the actions of policymakers and practitioners and highlighting divergences between policy and practice.

1.5.1. Empirical significance

As Skok and Tahir (2010) note, there is a lack of research on UAE innovation and its ecosystem, in particular grounding the lived experience of UAE culture. This gap is addressed by compiling qualitative data from a survey of 60 Emirati start-ups firms in the software, non-carbon economy and life sciences sectors. The research findings guide entrepreneurs in the software, non-carbon economy and life sciences sectors by identifying key success factors for firm creation, growth and internationalization. At a sectoral system of innovation level, the framework and analysis developed will help guide search, diligence analysis and policy formulation for UAE fund-managers, associated professionals, university commercialization centres and clustering policymakers. Finally, this research has significance for use Ministries (Economy, Industrial Affairs, Infrastructure Development) by identifying gaps and inefficiencies (and areas to be amplified) in the promoting software, non-carbon economy and life science firm development.

1.5.2. Theoretical significance

Whilst authors, for example Al-Naqeeb (1990), Al-Waqfi and Forstenlechner (2012) and Al-Ansar, Xu and Pervan (2014) have explored innovation in a Gulf context, unlike this research they do not inter-related the firm, sector and economy/society levels as is done here, using the multiple perspective approach thus adding to theory of Gulf innovation ecosystems. Secondly, the research adds to the body of theory on innovation in a resourced-endowed context by exploring how UAE's culture and context impacts on firm, sector and economy levels of innovation activity moving beyond the general comments made by authors such as Sachs and Warner (2001). Thirdly, North (2009) and others suggest that adoption of western market relations is the only transition route from oil-dependency, a strategy at odds with UAE's vision of *modernization without westernization*. The contribution of this research is to suggest that UAE is evolving a novel transition strategy towards an internationally competitive knowledge-based economy. Fourthly, critics of Etzkowitz's (1983) Triple Helix theory, such as (Inzelt 2015; Balzer and Askonas 2016 and Reich-Graefe 2016) contend that it cannot apply where institutions are immature and emerging: this research argues that strategically directed institutional arrangements in an emerging economy can overcome these criticisms, thus adding to the body of Triple Helix theory. Finally, by synthesizing the multiple perspective theory with ecosystem theory in a new framework, the research adds to the body of innovation tools available for analysing other resource-rich contexts.

1.6. Research problem

Migrating an economy and society from oil-dependency into becoming one of the global foremost knowledge-based innovative ecosystems, as *Vision 2030* targets, is a complex socio-technical challenge. Adopting Linstone's (1981) multiple perspectives helps understand the processes and the interaction between diverse levels, multiple causations and unintended outcomes. Emiratis support *Vision 2030* and UAE has the resources to invest in its achievement. The implementation challenges, however, remain enormous since the entire social, cultural and economic fabric of UAE must change. In particular, *Vision 2030* paints a picture of an economic vibrancy built upon an indigenous knowledge base, suitably inter-connected with advanced international research and new product development networks exploited by UAE companies. In short, a new, sustainable ecosystem: the first of its kind in the Arab world and the first successful migration from oil-dependency to a knowledge-based sustainable model. It is this diversification process towards an innovation-led knowledge-based economy resulting in a sustainable innovation ecosystem targeting emerging technologies, that this research seeks to analyse.

1.6.1. Gaps in literature

Transitioning from commodity production towards a service-oriented and knowledge-based innovation ecosystem is a problematic transition, as is demonstrated by the number of economies remaining in the middle-income group (WB 2015). The application of one transition model (Etzkowitz's 2008) Triple Helix (TH) demonstrates the problem: transition requires 'thick' institutional arrangements capable of generating and exploiting new knowledge embodied in goods and services, however by definition emerging economies have 'thin' institutions that they are in the processes of developing. Balzat *et al* (2004) and Shapiro (2011) point towards this problem, however, neither offers an alternative framework. This is one of the important gaps in the research literature that this research will fill.

	Gap in literature	**Expected contribution**
1	Lack of theorisation for the knowledge-based innovation ecosystem	• Using the multiple Perspective Systemic theory to theorise the knowledge-based innovation ecosystem
2	Lack of case evidence for innovation ecosystem in Gulf context and in specifically the UAE.	• Deep understanding of the Emirati transformation toward knowledge-based innovation economy than the traditional Oil-based economy.
3	Lack of systematic analysis and understanding of UAE's 2030 Vision toward an innovation-based, knowledge-based, or non-Oil-based economy.	• Building a systemic framework for knowledge-based innovation ecosystem that uncover the complexity and interaction between innovation resources, stakeholders, and processes.
4	Lack of empirical evidence that support the use of Multiple Perspective theory in the area of Innovation in general, and knowledge-based Innovation more specifically.	• Develop a Kantian multiple view (i.e. TOP) for the foundations, challenges, and mechanisms of knowledge-based innovation ecosystem.

Table 1.3: Gaps identified in literature from Introduction chapter

As Al-Naqeeb *et al* (1990) note, there is little empirical literature grounded in the Gulf experience of building a KBE. In part this is because no Arab country has yet completed this task. This research will argue that UAE is nearest to doing so and offers a new framework that can act as a route-map for policymakers and practitioners guiding transition processes. Grounding this research in the UAE instead of an international comparative study means that the generalization of conclusions could be limited. This is the case with all grounded research, all of which requires re-contextualization to be generalized. The aim here is to provide a new intermediate-level theory (Llewellyn 2006) of use to policymakers and practitioners.

In summary, at this stage (i.e. from this introduction and before my literature review) Table 1.3 can already identify key gaps in the literature, upon which my research can either comment or fill the gap; further gaps will be added throughout the literature review.

1.7 Research Approach & Theory Building

This research has a three-stage research design for constructivist grounded theory, based on Charmaz (2007) as follows: (a) *creating an explanatory framework based on previous research and literature gaps* (b) *using the framework to gather data explaining reality* (business cases and ecosystem overviews), then (c) *theorizing* (with reference to the initial framework and literature) to arrive at new theory.

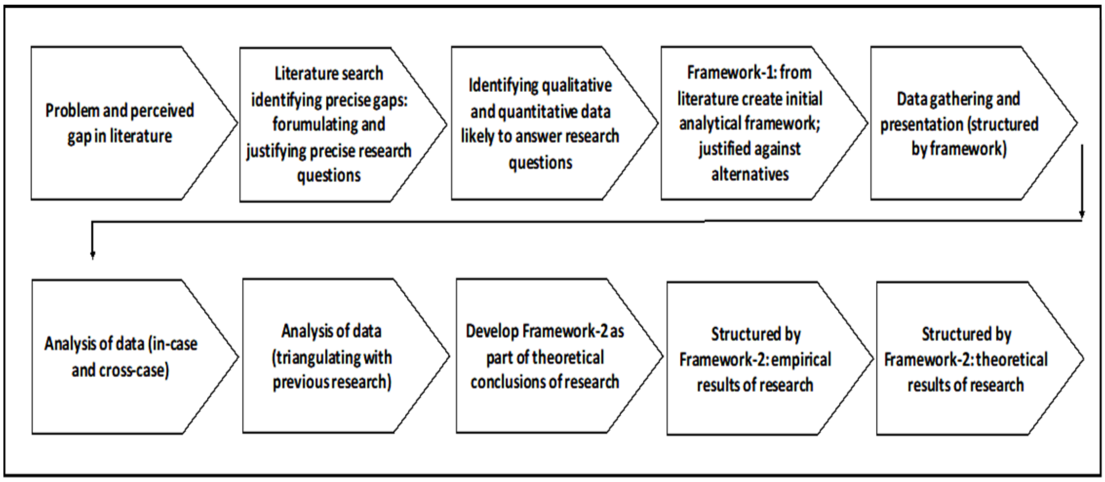


Figure 1.2 Flow diagram of using Charmaz's (2006) constructed grounded theory in research

Theory building had four stages; first: a conceptual framework that included the factors of innovation ecosystem as addressed in the literature. Second: a revised theoretical framework based on the multiple perspective theory was built in chapter 3 after reviewing and contrasting alternative theoretical lenses. Third: drawing from the interviews and survey data using, and advanced version of the framework is built. Fourth: A final framework is drawn from the operational elements of the innovation ecosystem in the UAE context. Research methods texts such as Bryman and Bell (2011), Gummesson (2000) and Yin (2008) recommend Charmaz's approach, in particular for exploratory research. Triangulation between theory, data interpretation, and reflections is maintained along this thesis (Denzin 1978). As will be detailed in the methodology chapter, data was gathered using both mixed methods. Qualitative methods (including interpretations for numerical data in the survey) and citing an extensive body of policy and report data from the context of UAE (Ghauri and Gronhaug 2005). The research surveys 60 start-ups (innovators) in the software, non-carbon and life-science sectors, and interviews with policymakers and the leaders of the Khalifa Fund producing a case study of the Khalifa Fund and its role in the emergent innovation system in UAE. By blending interviews judgmental statements and numerical data in the survey, this research builds a theoretical framework out of case study evidence as demonstrated in Eisenhardt (1989 and 2007) (See Table 1.4) and noting the other types of contributions from research outlined by Nicholson *et al* (2018): incremental, revelatory, replicatory and consolidatory.

Dataset	Sample	Gathering techniques
Previous research		Systematic search and summary of previous empirical research on UAE innovation and entrepreneurship
Survey *View of all current Start-ups served by Khalifa Fund*	60 participants	Online questionnaire + follow-up: 20 x 3 sectors
Views and experiences of Policy makers, incubation managers, and university commercialisation units	21 interviews	Semi-structured interviews

Table 1.4: Summary of data Sources

The reason for using survey and some closed-ended questions is to get a bigger response rate within the time limitation and the closed clutter of UAE, where confidentiality is key in organizational practices. 43 factors found in the literature and others explored during the interviews. Then, closed ended questions addressing these factors have been raised.

1.8 Thesis Structure

Chapter -1: Research Introduction

This chapter introduced the research background and points out the key research problem, research gaps, and research significance. The research questions and objectives are also demonstrated in this chapter and the potential contribution towards each research gap has been addressed.

Chapter-2: Literature review

Chapter 2 and 3 achieve objectives 1, 2 and 4 of this research: reviewing relevant previous literature, combining key factors into a new conceptual framework with which to analyse UAE innovation and doing so with a deep understanding of UAE's context and culture. Beginning by clarifying the nature and characteristics of knowledge (using Dewey's 1992 pragmatic technology (Hickman 1992) the chapter argues for the importance of building basic research and absorptive capacity to close gaps between science and technology and the importance of knowledge-based innovation institutions such as intellectual property rights and exploitation and the availability of risk capital and early routes to internationalization. It explores the issues of motivation and incentives facing innovators in an oil-rich context and UAE's cultural heritage. Exploring the application (or critique) of Triple Helix institutions, the chapter examines research on university-industry links in general and the UAE and their association with spatial clusters and the wider innovation ecosystem. The chapter concludes by summarizing gaps in the literature and how they relate to the research questions.

Chapter-3: Theoretical Framework

This chapter explores the theoretical genealogy on networks and ecosystems, using Linstone's (2009) Multiple Perspective Theory and TOP (technical, operational and personal) approach. Critically evaluating this approach, the thesis considers alternatives and critiques looking at the application of MPT to emerging economies and societies, taking UAE as a paradigm. It identifies definitions, factors, boundaries and causal relationalities to inform my framework building. The need for a new framework is justified by a critical evaluation of existing frameworks and how they apply to an oil-rich economy in rapid transition towards a knowledge-based economy. Drawing on Chapters-2 and 3 and using Linstone's tools, this chapter defines the factors in the framework, their boundaries (at firm, sector and economy levels) and the causal relations between 'nested' levels of analysis and the factors. The chapter concludes with a section on how the new framework works (Framework-1 in Charmaz's [2008] terms) and the use made of it in guiding data gathering, presentation and analysis.

Chapter-4: Research Methodology

This chapter demonstrates the philosophical paradigms and methodological threads used in this doctoral thesis and in doing so meets objective 3 of this research (section-1.3). It justifies the ontological and epistemological rigors (Bhaskar 1986) and social constructivism of the factors that shape the innovation ecosystem (Parker 1986). The research design of constructivist grounded theory is thoroughly explained and justified to be rooted in the empirical evidence and the theory development process. The chapter then details population and sample choices, justifies data gathering techniques (self-completed survey and semi-structured interviews). This chapter then justifies data presentation (structured by the framework and emerging top-level themes) in the form of a quantitative data chapter (using conventional statistical analysis) and a qualitative data chapter featuring a case study of the Khalifa Fund (informed by analysis of 60-firm survey and analysis of the UAE culture and context.

The chapter details data filtering following Silverman (1993) and Huberman and Miles (2002) by identifying primary and secondary codes, re-familiarize with the data (See Glaser 1978 & Yin 2003) reducing major themes to three or four and taking Occam's Razor to secondary codes before the line-by-line coding Charmaz (2006) suggests is appropriate in areas of emergent research. Analysis is also structured by the framework and emerging themes carefully triangulating between literature, data and own sense-making (Schein 1985) to answer the research questions. The chapter concludes by pointing to limits on generalization from this research, ethical considerations and the nature of theory expected.

Chapter-5: UAE innovation ecosystem – qualitative data

This chapter begins with 'scene setting' referencing previous empirical research relevant to the innovation context and culture of UAE, in particular work relating to incentives and motivation in an oil-rich context and previous work on research, commercialization and companies in the software, non-carbon and life-science sectors, such as (Audretsch 1985; 1998. Then, using data from 21 interviews and data with policymakers, Incubation Centre managers and the fund's managers.

Chapter-6: UAE innovation ecosystem – quantitative data

This chapter begins with a statistical overview of the UAE context, the detail from the 60-firm survey. Using qualitative data techniques for presentation and quantitative techniques for analysis (correlations and other statistical tools), the chapter presents and discusses the conclusions of my quantitative work. The chapter constructs a case of centred on the Khalifa Fund, structured by the factors in Framework-1 and using Linstone's (2009) MPT) and TOP tools.

Chapter-7: Analysis and Discussion

This chapter answers the research questions and in doing so identifies the theoretical, empirical, policy and practice results of my research. Following Bryman and Bell (2012) this is done by triangulation; as Yin (1994:103) suggests comparing data with the related theoretical propositions and gaps that led to the case study investigation for which is referenced structured by framework-1 and themes emerging from coding. Each section considers what previous research leads us to expect, then what data reveals, following which an interpretation of the results theoretically and empirically is suggested.

Chapter-8: Conclusions & Contribution

This chapter summarizes the answers to the research questions, comments on the validity and generalization of the research results and then details how the research contributes to bodies of knowledge theoretically, empirically, for policy and for practice and practitioners (Linstone's 2009 TOP). The chapter concludes by considering further research and suggests a plan for dissemination, publications and impact.

CHAPTER TWO: LITERATURE REVIEW

Introduction

The previous chapter addressed the research problem, the research gap, and significance. The lack of theorisation and understanding of knowledge-based innovation ecosystem is demonstrated in the current chapter. Although this chapter reviews the previously published researcher and revisits all the research questions mentioned in section 1.4, it offers a thorough answer to Sub-RQa, *What are the key foundations and aspects of the innovation ecosystem in the UAE?* The chapter meets objective-1 i.e. reviewing previous research, establishing the basis for chapter-3, in which the second part of objective-1 is achieved – creating a conceptual model of a knowledge-based innovation-led economy in the context and culture facing UAE.

This chapter sets the key concepts of innovation, innovation systems, innovation knowledge, and innovation ecosystem that have been employed in this thesis. The first section addresses the definitions of innovation and the key types with examples. Then develops a rhetoric meaning of the so called "innovation knowledge" that synchronises with nature of non-oil economy and need for innovative services, processes, and techniques. Afterward, the researcher offers a critical review of systems thinking literature and how innovation scholars define the so called "innovation systems". The second section addresses the network of stakeholders that create and share innovation knowledge then it addresses the characteristics of innovation ecosystems in developing economies, including our research context of the UAE. The third section discusses the evolution of innovation in the UAE and pinpoints the key factors (cited in the literature) that shape the innovation ecosystem in the country. The last section redefines the research gaps and emphasise on the plan followed in writing Chapter three and the rest of this thesis.

2.1 Innovation as a system

2.1.1. What is innovation?

This research conceptually differentiates innovation, entrepreneurs and entrepreneurship, whilst arguing that they are inextricably inter-linked. Innovation is more than novelty or branding: it is a *new solution to customers' problems*. Dewey's

(1992) idea of pragmatic technology captures the nature of technology as much more than technical; it encompasses the social use-usefulness-usage-usability of the new solution. Innovations, Freeman (1982) argues, may be radical or incremental, product or process, original or re-combinatory, disruptive (Christensen 2008), and tangible or intangible (Haskel and Westlake 2018). Innovations may solve problem customers are a yet unaware of (iTunes, Walkman) and increasingly rely on platforms (Cusumano 2006) and complementarities. If innovation focuses on the solutions, entrepreneurs focus on the technical, organisational and personal aspect of Linstone's TOP: as Harrison (2002) argues, marshalling the resources and creating the legitimacy in the eyes of partners necessary to profitably sell the product. For the purpose of this research, it is not possible to have entrepreneurs without innovation nor is it possible to innovate without being entrepreneurial. Here, entrepreneurship as an abstract noun denotes policy discourse around encouraging entrepreneurs and innovation. It is of course possible to be entrepreneurial within social innovation projects and public services; these are not the concern of this research. Nor are entrepreneurs creating lifestyle (i.e. family income, low growth) businesses.

'Open' and 'closed' innovation processes are ideal types and as Zynga (2018) argues, there is insufficient research on how companies move from one to the other. Bogers *et al* (2017) note that in multi-level innovation scenarios, one level may be open (the company) and other levels (finance, regulation) closed. Lyu *et al* (2020) argue that the more open the project the more radical the innovation, a conclusion not validated in areas of formal science such as DNA genetic engineering (Isaacson 2021). Openness is always a matter of degree: only a well-resource project *without any aim or purpose*, would be completely open. Open and closed are therefore a balance between preparedness to accept external ideas, while disciplined to the purpose of achieving a particular outcome in a particular technological timeframe. Innovation is the process of translating an idea into an original product or service which satisfies a specific consumer need (Birkinshaw *et al* 2008), which as Lin *et al* (2009) Saebi *et al* (2015) may be confined to a new business model: iTunes digital music being an example.

Social innovation (Avelino *et al* 2019; Pei 2020) may be different in that resolution of an intractable social problem, is likely to involve attitudinal change as living labs (Engels *et al* 2019) research shows. Wittmayer *et al* (2019) introduce the interesting idea of distributed agency, i.e. altering collective consciousness as part social innovation.

Innovation equals invention that generates value for the world by making something faster, better, cheaper, and it gives someone some great satisfaction. Invention is an idea a technology or a path in and of itself it does not generate value so these two are not the same thing but sometimes you see them interchanging (Dasgupta et.al, 1982; Spulber, 2013). So, in this thesis the researcher argues that innovation equals invention by product of commercialization measured in value added [Innovation = Invention x Commercialization] (Mazzarol, 2013). When we look at this equation of innovation something of value it requires a new idea and then it requires someone or some organization that is going to commercialize that idea and to make it a value to the world.

An idea by itself is not valuable: it is the commercialization when combined with it that makes them extraordinarily valuable. When we look at the idea, people think that this drives innovation it is in fact the commercialization aspect of it is difficult. If you look at the most innovative company in the world today, which was cited by business insider as “Apple”, the underlying inventions that created Apple’s great innovations starting with the Mac, did not come from themselves. It came from Xerox Parc and it was windows icon mouse pointer. That invention they commercialized to create innovation, which create terrific value in the marketplace and for their customers and for themselves are investors as well.

Likewise, after that you look again that the invention for the underlying in enabling idea technology from the iPod was MP3, which did not come from Apple. Again, that came from Fraunhofer, but what Apple was terrific at was commercialization to create innovation and to create value for their customers and other stakeholders.

There are five primary types of innovation Their disruptive breakthrough radical incremental and sustaining (Oke, 2007; Damanpour *et al* 1989). First, is *disruptive innovation*, which creates new markets and new categories of customers. They utilised old technology new waves and harness the power of modern technology to create new business models. For instance, the development of the personal computer which brought the mainframe to the home. Second, is the *breakthrough innovation* an unexpected solution that creates a global paradigm shift. They employ new technology that customers don't realise they need it until they experience it first-hand forever changes life as we know. For instance, electricity one existed changed the human life. Third, is the *radical innovation* that reshapes an existing industry convention to create something new. It brings new benefits to the consumer, and it is a catalyst for creating new markets to meet demands of the current generation. An example would be the development of digital photography and fall of Canon's traditional cameras. Fourth, is the *incremental innovation* improves product overtime through small changes to add new features that we can improve the overall design and it's driven by how consumers desire to use the product a good example would be the evolution of the bicycle Fifth, is the *sustainable innovation* when improvements are made to an existing product by predicting consumer needs. It does not shift the company's goals it expands the company product line giving the consumer more choices and it keeps the business alive by retaining loyal customers. A good example would be the development of the iPhone overtime.

While disruption is often used is a general sense to mean radically new, Christensen (1997) employed the term in a much narrower sense, important for his later work on avoiding disruption. His idea was that market leaders incrementally innovate (listening to customers) while the disruptor focuses on entirely new ways to solve the customers' problem. A recent example might be car manufacturers, most of whom incrementally improve their models. However, the customer problem is getting from A to B. Didi (China) and Uber or Lyft (US) solve the customer's problem with App-called taxis, or Tesla solve the problem by an electric-car and Google with its proposed autonomous vehicle: these are true disrupters. As Hang (2015) notes, since disruption is a radical innovation is comes accompanied by new business model (renting cars, free car-rented battery, ownership of miles travelled) and governance arrangements. As Chesbrough (2010) and Christensen (2015) note, disruption can be easier in services, which are not 'encumbered' by inherited capital equipment and instead need to alter ways-of-working and relations with customers investing less in new tangibles. For this reason, also, Wan *et al* (2015) argue that disruption can be easier in emerging market situations, where the regulatory framework may be emerging and the *advantages of backwardness* available. Si *et al* (2020) give examples as does Ozalpt *et al* (2018). Where disruption can use an existing platform infrastructure (such as online sales in UAE using the

Amazon platform) disruption becomes less costly; also, an advantage (market entry) to the platform provider. Disruption from this perspective is best conceptualised as an ecosystem rather than network effect. The former's self-management and adaptability contrasting with the (possible) tight central control found in networks. Ramani *et al* (2014) show how some bottom-of-the pyramid innovation in India, disrupted previously imported customer purchases.

Since Schumpeter (1934) we have understood that it is technology diffusion, rather than original innovation that creates economic growth. Diffusion is controlled by a wide range of technological and cultural factors. For example, the Chinese direct debit (QR-code) payments system appears less costly and faster than cash or credit card payments. Yet, for cultural reasons Japanese shoppers often continue to use cash and Europeans credit cards rather than join Baidu. Additionally, as Bloom *et al* (2019) argue macro-level constraints (disposable incomes being the prime example) limit diffusion.

Internet-of-things (IoTs) is an interesting current example revealing the nature of innovation (Vermesan and Friess 2014). Bluetooth signalling from a vast range of devices can instigate action from ordering milk as the fridge signals low stock to a call from the Doctor who has learned that blood pressure is high. Thus, IoTs relies on interoperability between 5G bandwidth and receptive platforms (Ahlgren *et al* 2016): it is what Soldatos *et al* (2015:14) term an open-source platform capable of B2B, B2C and G2C or technically (Robert *et al* 2017) device-to-device access layering via device-to-Cloud, device-to-Gateway or web-of-things. Williams (2018) believes IoTs will disrupt healthcare, finance and vehicles and Porter and Heppelmann (2014) foresee it as the engine of big data and Hwang *et al* (2015) disrupting logistics. Already Bosch (2019) notes several IoTs platform technologies exist: Bosch's IoT Suite, GE Digital's Predix, ABB's Ability, Sisco's IoT System, and Siemens' MindSphere.

What are we to make of IoTs diffusion? Roger's (1983:370) diffusion of innovation theory draws attention to applied R&D, development, commercialisation, adoption and consequences resulting in competitive advantage based on observable interoperability and superiority (including as Barrena-Martinez *et al* (2020) note, the absorptive capacity to service the innovation). For Tornatzky and Fleischer (1990) Roger's theory holds when the technology, organisational and environmental conditions are right: in short, the technology is not inherently superior, its ambience allows it to be superior resulting Hoti (2015) says in customers choosing the diffusing technology rather than 'old' alternatives. This is quite different from Christensen's (1997) idea of diffusion. He would argue that IoTs diffusion depends simply on whether from a customer's perspective, IoTs solves problems in a better way than the alternative. This poses the question: to what is IoTs an alternative. Taking our two examples: the milk supply is dependent on memory, is IoTs superior – yes. Is IoTs superior to regular visits to the Doctor or undertaking self-tests of blood pressure and then contacting the Doctor – yes/perhaps. Thus, even if ambience presents barriers (of the sort Tornatzky and Fleischer envisaged), Christensen's perspective is that IoTs will successfully diffuse. Recent attention around *smart cities* (Kitchin 2014; Tornaghi 2016; Maye 2019) draws attention to ambience as enabling innovation, though as Sennett (2018) smartness can be interpreted as human relationalities and not simply technology advances.

What then is innovation? Innovation is a new solution to a problem customers have (polluting vehicles) or may not perceive they have (IoTs signalling). It is the result of purposive search blending project openness and closure, successfully commercialising and diffusion, appropriate to context and culture.

2.1.2 Innovation Knowledge

Coombs and Miles (2000) argue that three approaches to define innovation knowledge have evolved: assimilation, demarcation and synthesis, renamed by Gallouj (1994, 2002) and Gallouj and Savona (2009) as technologist (goods-dominant), service oriented (differentiation-focused) and integrative (tangible and intangible customer experience). As Miles (2016) notes, differences in terminology partly reflect origination of concepts in different traditions e.g. innovation research, marketing or business development. However, Carlborg *et al*'s (2014) point remains valid that each of the three perspectives takes a fundamentally different view on innovation knowledge and its relationship to technology.

Assimilationist or technologist approaches to innovation knowledge as an appendage to manage physical resources to maximize organizational benefits (Gallouj; 1994;

Coombs and Miles, 2000; Howells & Roberts, 2000). In the same school of thoughts, Barras (1986) define innovation knowledge as a process of diffusion and orchestration of different internal and external organizational factors to stimulate the reengineering of previous innovation.

Gallouj and Weinstein (1997) criticized this approach as it fails to capture the subjective experience and co-production inherent in service and process innovation (Normann 2002). Riedl (2011) exemplifies this approach, not in the sense of viewing innovation knowledge as an appendage to artefacts, rather viewing as a construction of technological tools, de-emphasizing the co-production and subjective experience of innovation beneficiaries (Preißl 2000).

Demarcation is another approach of innovation knowledge that emphasizes on intangibility and co-production, however, essentially from a marketing perspective. As Mercier-Laurent (2011) points out, novelty is an insufficient condition for innovation, which is characterized as a new way of solving customers' problems.

The third approach to innovation knowledge synthesizes the technological and marketing approach, going further to posit a *servitization* of the economy blurring boundaries between goods and services into integrated solutions, systems and ecosystems (Weinstein 1997; Coombs and Miles 2000; Gallouj 2002; Gallouj and Savona 2009; Carlborg *et al* 2014). This perspective recognizes that much of what happens within manufacturing is operational knowledge, design processes, procurement, financing.

Innovation knowledge as emphasized by Janssen (2015) is socio-technical system in which, a renewal of an existing operations of product/service, which is put into practice, and which provides benefit to the organization that has developed it. Innovation knowledge is the added value that the renewal of service/product/processes provides the customers. It is the adaptation of this renewal to the broader context, and it must involve some element that can be repeated in new situations, i.e. it must show some generalizable feature(s) (Janssen, 2015). This neo-Schumpeterian view of innovation knowledge subsumes technology and process into a new solution for customers and readily aligns with the prospect of being part of a platform of services (Gawer and Cusumano 2002; Windrum and García Goñi 2008). Also, given the diversity of values and value-flows, this approach accommodates new business models: effectively this is the model developed by Gallouj and Weinstein (1997). De Vries (2006), Gallouj and

Toivonen (2011) proposed a framework is user/customer-oriented: innovations are evaluated by their value to the customers: solving problems in a new way, combining problem solutions and/or solving new problems.

The Gallouj-Weinstein model specifies distinct types of innovations knowledge. Basically, it defines innovation as any change affecting one or more of technical (X), competence (C) or final (Y) characteristics. It features six types of innovation knowledge: (1) incremental improvement such as online booking/payment; (2) packaging of services substituting for fragmented offers; (3) new service architecture such as a platform; (4) formalization, such as clearer standards, click-throughs, information access; (5) radical innovations that create a new way of solving problem such as online shopping and other dis-intermediating services; and (6) ad hoc innovation (perhaps the development of Linux or the 'accidental' growth of VoIP). Innovation knowledge usually feature (Y) and (C) and sometimes (X). This is how innovation knowledge is investigated in the current research as a backdrop to understand factors of innovation ecosystem in UAE's non-carbon, software and life-sciences sectors.
In the next section, the research introduces his view of innovation knowledge as a system. In doing so, he reviews the literature of systems thinking to be used to define innovation systems that will be used further in the current research.

2.1.3 Systems thinking

Physical sciences can identity systems wholly representing the regular interaction of parts forming a unity (such as the gravitational system) or that together cause a functional output (the digestive system or a chemical reaction), Hargreaves and Podems, 2012; Ramage and Ship, 2009, Sterman 2002). When including humans, systems are simplifying constructs of interacting factors (some of which may be non-human), within assumed boundaries from its environment, that cause social results (von Bertalanffy 1981). Systems approaches, Checkland (1981) notes, draw on biological analogies, but in the case of social systems simplify assumptions of factors, causal relationships and boundaries. Boulding's standard classification of systems is shown in figure 2.1.

BOULDING'S CLASSIFICATION OF SYSTEMS

TYPOLOGY	FEATURES	CLASS
1 Framework	static structure	Physical or
2 Clockwork	simple dynamics	mechanical,
3 Thermostat	self-regulating	Physics
4 Self-maintaining	open, simple life	Biological,
5 Genetic-societal	eg plant	botanical, and
6 Animal system	self-awareness	zoological
7 Human	conceptual	Human and
8 Social system	values, emotions	social
9 Transcendental	beyond humans	

Figure 2.1: Boulding's systems classification (Kast *et al* 1972)

Emery and Trist (1981) argued that the dangers inherent in social systems theories are when they become 'closed' systems that fail to interact with environmental stimuli and suggest deterministic causal relationships between factors. Examples of general systems falling into the deterministic trap arguably include Parson's technical, organizational and institution functionalist sociology; Pareto's equilibrium economics and Malinowski's behavioural anthropology; each of these is characterized by being a 'closed' system i.e. not subject to extraneous influences and some are composed of factors with contested meanings.

Carefully used to generate hypotheses or modelling (Hanneman and Riddle 2011; Helbing 2012; Holz et. al 2015) systems thinking is however a useful tool. Since the mid-1950s, systems thinking (Cabrera 2006; Meadows 2008) has spread across research disciplines, including as Williams and Hummelbrunner (2011) note, cybernetics, complexity theory, soft and critical systems, network theory, and learning systems, as Dyehouse *et al* (2009) and Merril *et al* (2013) suggest, using what Lane and Oliva, (1998) termed soft systems i.e. open and dynamic. Examples include Giddens (1987) structuration system and Senge's (1990) learning system. Dynamic systems according to Meadows (2008) are characterized by non-linearity (effects are not pre-determined, and effects may not be proportional to cause), and they are autopoietic (Krogh and Roos 1995) i.e. feedback brings self-sustainability. Sterman (2002) illustrates a business system (See figure 2.2) in which (B) is a balancing loop, interacting between stock factors that alter with flows, the point being to model simplified interactions for the purpose of helping visualization by non-experts and suggesting change scenarios.

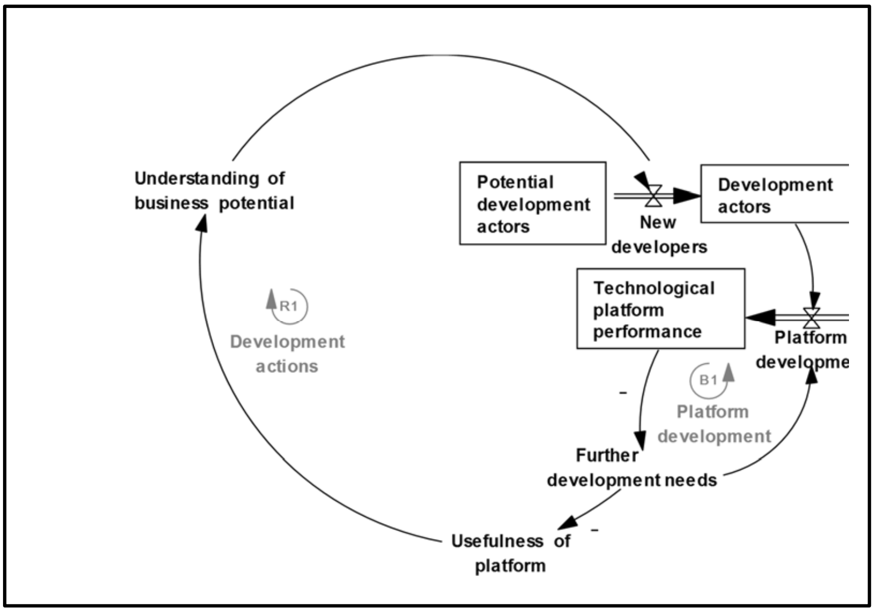


Figure 2.2 Self-correcting systems (Adopted from Sterman's, 2002, p10)

The simplest systems models Ylén *et al* (2014) and Holz *et al* (2015) suggest, (such as input-transformation-output) visualize transformations, which if established are then subject to quantification. An advantage of simple schematic models, as Chen (2005) and Merrill *et al* (2013) argue is that they readily highlight enabling or disabling factors. Thus, for example, number of input factors, and cost of transformation will compare with value of output. Such models are particularly useful if all factors are measured in the same quantitative unit, such as money or physical product.

Social science systems differ fundamentally from those in physical sciences, which are discovered and revealed by empirical research; whereas social science systems are social constructions – the boundaries, variable and causal relationships in which are subject to choices. This is the meaning behind Box's aphorism that *all models are wrong, but some are useful*: degrees of non-linearity in open (social) systems trade-off variables and flows to simplify. These characteristics of open systems are also found in ecosystems.

2.1.4 Innovation Systems

The concept of the innovation system stresses that the flow of technology and information among people enterprises and institutions is key to an innovative process (Freeman, 1995). It contains the interaction between the actors needed to turn an idea into a process, product or service on the market (Musiolik et.al, 2020). Systems of innovation are frameworks for understanding innovation which had become popular particularly among policymakers and innovation researchers first in Europe, but now anywhere in the world as in the 90s the World Bank and other UN affiliated institutions accepted (Mohamad and Songthaveephol 2020).

The concept of system of innovation was introduced by Lundvall in 1985, however, as he and his colleagues would be the first to agree and as Lundvall himself points out the idea goes back at least to the Friedrich List's conception of the national system of political economy 1841 (Lundvall et.al, 1988). This was later called the national innovation systems (Freeman, 1995). Christopher Freeman coined the expression national innovation system or in his 1988 study of the success of the Japanese economy (Goto, 2000; Freeman, 2002).

The concept was similarly used as *national system of innovation* or *national innovations System*. It was later applied to regions and sectors. According to the innovation system theory, innovation and technology development are results of a complex set of relationships among actors in the system, which Includes enterprises universities and research institutes (Lundvall, 2007).

Innovation systems have been categorized as international innovation systems, regional innovation systems, local innovation systems, technological innovation systems and sectoral innovation systems (Asheim & Coenen, 2005). There is no census on the exact definition of an innovation system and the concept is still emerging. Innovation is often expressed as the result of the interaction of money and ecology of actors and the term innovation ecosystem is occasionally used to emphasise on the sequential relationship between all resources, processes, and actors that shape a sustainable innovation (Mohamad and Songthaveephol 2020).

Since the success of Silicon Valley and as Gordon (2015) notes, subsequent US leadership in the information and communications (ICT) set of general-purpose technologies, theorists and policymakers have striven to replicate what Baumol (1990) terms *productive entrepreneurship*. While researchers have previously focused on spatial clustering (Castells 1998, Porter 1995), or the commercialization of formal research (Etzkowitz 1983; 2000) or the availability of risk capital (Harrison and Mason 1992), there is now a burgeoning research and policy using the idea of innovation ecosystems.

Dissatisfied with theorizations of innovation systems, authors such as Stam (2015; 2015a) invite researchers to challenge tautologically self-referencing formulations of the idea. Isenberg (2014) challenges researchers to empirically evidence connections between start-ups and growth, incentives and incubation. Besides, he calls for *a systemic investigation for the gap between the policy makes and the start-up owners on what makes innovation system*. As Phan (2004) argues, if the idea is robust, the presence or absence of innovation ecosystem will correlate (or not) with start-ups and where gaps in ecosystems can be identified, will form a policy agenda.

In innovation systems, Cusumano's (2010) idea of platforms is important i.e. hosting a collection of services that function together to implement end-to-end processes whereby each service provider benefits from the services offered by others. Obvious examples are Ant Financial and Tencent; the now ubiquitous Chinese e-payment systems replacing the cash-economy in China across all payment sectors with direct debiting and are leapfrogging western payment platforms that are mediated through (costly) credit cards (see *Economist* 170817). For Riedl (2011:90) the main aspect of innovation ecosystems is a central platform bringing all agents together. This is a useful descriptor of the technical aspects of ecosystem; however, insufficient grasps how social agent actions shape successful platforms and continue reshaping them.

This research focuses on the generalization of the innovation ecosystem concept in the UAE as a particular type of developing economy, noting and that other systems-based models, such as Porter's clustering and Etzkowitz's Triple Helix have been criticized for their lack of application to developing economies, often because they assume an institutional thickness found wanting (Amin, 1994). The ecosystem concept differs from these previous systems approaches by centre-staging the innovator rather than institutions; as will be argued, by using the TOPs approach, analysis here can systematically move between technical, operational and personal perspectives.

Epistemologically, the concept of ecosystems has a long history. Schumpeter (1939) deploys the idea of evolutionary processes to mean dynamism, with later authors, such as Nelson and Winter (1982) modelling innovation in terms of selection, inheritance, sustainability and variation – the principles of natural selection. This approach became embedded in social theory, such as North's (1990) neo-institutional theory.

These ideas debunk neoclassical economics view of the firm as a passive subject of its environment. Theorizing evolutionary economics, Hodgson (1993) suggests that for firms and networks, selection may be ontological: a Lamarckian evolution by purposive learning. This is important, since as Dawkins (1986:223) and Archer (2003) point out, social theorizing without active agency is a precursor or determinism. Bookstabler (2017) for example introduces the idea of *ergodicity* (not varying with time or experience) to challenge the rational-behavioural assumptions in neo-classical economics. He argues such assumptions deny the possibility of *emergences* from ecosystems, since radical uncertainty is agent-based (for example, some agents sell more as prices fall or buy more as prices rise). As Beinhocker (2006) argues: agents' purposive activity in an environment alters the environment. Farmer (2002), Frydman and Goldberg (2011) and Page (2011) each give examples from financial markets of agent behaviour not following neoclassical predictions resulting in the creation of new rational behaviour patterns – a new environment. System complexity can be mechanical, stochastic, dynamic, reflexive and strategic. The key point about ecosystems is their complexity arising from which, as Holland (2014) notes, *emergences* arise. Unlike complex physical systems, such as the rainforest, in complex agent systems signals are cognitively and emotionally interpreted the fanout (reach, scope) and hierarchic effects (across scales) derives from the non-additive, unpredictable nature not only of exogenous stimuli, but also of agent's reactions to the stimuli. Put simply, the rainforest tree may react to global warming *ontogenically* (i.e. biological change), whereas the entrepreneur and innovator reacts because of reflexivity creating (potentially) more radical new patterns of action – emergences – a new grammar of rational behaviour (Mitchell 2009).

Discussion of the sectoral systems of innovation (SSI) approach in section 3.1, argued that while useful to structure descriptions, it is lacking as an analytical framework. Institutionalists, such as Scott (1995) and North (1995) recognise that some cities (Morgan 1997, Gertler, 2001; Sassen 2015) and sectors (Nelson and Rosenberg 1993; Saxenian 1994; Carlsson and Stankiewicz 1995; and Breschi and Malerba 1995) are more fertile ground for innovation than others. Many of these analyses are supply side technological systems with minimum agency. This researcher's perspective agrees with Lundvall (1992:2) that a *central activity in the system of innovation is learning, and learning is a social activity, which involves interaction between people*. In particular, Ogle's (2008) *ideas space* captures the best exchange of S&T creativity within clusters, spatial networks and generally SSIs. Geels' (2004) argument is also important; that demand side importantly 'pulls' innovation: Porter's (1990) notion of *discerning customers*. SSIs work best as space for the cross-fertilisation of ideas and complementarities and include as Herrmann and Peine (2011) argue visionary leadership, attract leading researchers and feature strong UILs, have other staff with competences available and can access capital in all its forms, including state aid.

SSI-building features prominently in *Vision 2030*, with software, non-carbon and life-sciences technologies amongst those highlighted, which will feature in the prestigious 2020 Expo – a process Acuto (2014) terms *worlding*. Perhaps because of UAE's success in some sectors (tourism; oil; finance; construction; logistics; aircraft maintenance) and its ability to resource the building of target SSIs, research led by the IMF (2016) praises the tax regime, and Davidson (2009; 2009a) applauds the *Dubai Model* of SSI-creation. Positive analyses of UAE's SSIs include Grant *et al's* (2007) suggestion that the target SSIs will be created, Mina's (2014) analysis of UAE as an inviting location for inward-FDI and Anwar's (2015 analysis of Emirate Airlines successfully creating a new SSI including a hub-airport and ambient attractive retail and cultural experiences. Ahmad (2014) too concludes that UAE has created a new SSI, in the telecommunications sector by outward-FDI into countries with difficult infrastructure and political environment including Afghanistan, Benin, Burkina Faso, Egypt, Gabon, Indonesia, Ivory Coast, Niger, Nigeria, Pakistan, KSA, Sri Lanka, Sudan, Tanzania and Togo. He notes that this model is more Mathew's (2002) network building model rather than the Uppsala model of internationalization to culturally close destinations. Researchers such as Al-Suwaidi (2011) reach similarly positive conclusions citing UAE's diversification strategy based on a stable exchange rate, sound fiscal policy and investment of oil revenues.

Other researchers reach less sanguine conclusions. Exploring UAE labour markets, Benchiba-Savenius (2016) point out the Emiratis prefer working for local employers and the Government rather than international companies. (KF Youth 2016) balance positive prospects with also pointing to labour market challenges, in particular the low rate of self-employment (3%, compared with 30% in Korea), the disincentive of high state benefits sustaining an inactive labour market for young unemployed (14% of age cohort), shortage of mentors and low business engagement with universities, and low business start-up by business professionals. Labour markets in most developed economies remain gendered. In UAE, Al-Oraimi (2011) argues, since 70% of university graduates are women the 40% labour market participation rate is too low; a point policymaker agrees with. AbuQamar *et al* (2015) found that half of UAE undergraduates have no knowledge of biotechnology and concludes that this makes targeting life-sciences questionable. This research comments on his findings. For the moment, it can be noted that half the undergraduates *are* aware of biotechnology – a promissory quota. Also noteworthy is Neves and Lammer's (2007) finding that the UAEU-FMHS (the Faculty of Medicine and Health Sciences) has published 1,369 papers in six years, half of these in international journals, suggesting that staff and post-graduates are keenly aware of life-science issues

Governances are an issue in every economy. Ulrichsen (2011) suggests that adopting KBE globalisation (economic) governances has been easier in UAE than adopting the social governances associated with globalisation, suggesting controversially that Emiratis remain too state-centric, perhaps an unfair criticism considering the development state discussion above. Buckley and Hanieh (2014) suggest that UAE property clusters (diversification by urbanisation) is over-exposed to high-value residential and commercial property values, an unsurprising conclusion referencing data only three years after the 2008 financial crisis. These are difficult issues, for example Sudjic's (2005) analysis of the edifice complex (dictators wasting resources on vanity projects) cannot apply to the UAE context. Even if the Masdar (non-carbon city) is less successful than predicted, it cannot be argued that it is other than a visionary attempt to create a sustainable SSI.

Research then suggests mixed evidence for the success of SSIs in UAE and calls attention to labour markets, motivation and the legal system as retarding innovative efforts. No clear picture emerges from previous research of how effectively the technical, operational and people aspects of innovation are integrating into deeply rooted sectoral systems of innovation in key areas such as life-science, non-carbon and software technologies; a gap that this research will help fill.

The idea of ecosystems originated in ecology (Tansley, 1935) and as Rowe and Barnes (194) and Blew (1996) point out is subject to various interpretations, principally (a) an organism inter-relating with its environment i.e. processual flows or (b) a description of spatially similar environments. From our viewpoint this etymology is important since (b) is descriptive, whereas (a) is a socially constructed set of boundaries and causal relationships rooted in Bertalanffy's (1981) general systems theory.

An attractive feature of ecosystems as a framework, is overcoming the linearity found in alternative frameworks such as Porter (1995, focusing on endowment) and Etzkowitz (2000) (mature institutions). Ostrom (2007) for example argues that since agents and institutions in an ecosystem differentially affect outcomes, there is a need for nested frameworks reflecting power in ecosystem interactions. In 2009, he notes that ecosystems are temporally specific to context and shaped by the quality of interactivity between unit of analysis (firm or network) and other major agencies. Since ecosystems are scale independent (Pickett et al, 2002) choosing system domain boundaries – in our case the footprint in which innovation occurs in UAE - is of great importance: sufficiently tight to be a system (i.e. causally create outputs), while sufficiently open to the environment to avoid negative lock-in: allowing for Holland's (2014) complexity and *emergences*. Aligned national ecosystems will adapt to changing international institutions if they are to avoid eutrophication and insularity; additionally, as Dietz et al (2003) argue ecosystems are subject to contagion as either the governances or performance or associated systems alters.

System sustainability, while allowing for change, is always problematic as Osborne et al (2014) show. In the case of ecosystems, Holling (2001) argues that sustainability with wider systems is important. In the case of UAE innovation, creating internationally leading companies in emerging sectors is a key aim of *Vision 2030*; hence successful basic research, participation in international R&D projects and commercialisation of frontier technologies are each important. External partners, such as I-FDIs (inward foreign-direct investors) and research and development (R&D) collaborators are likely to attach different success criteria to UAE's ecosystem as Bateman et al (2011) suggest, as are different individual agents (Farber et al, 2002) and different disciplines (Nicolson et al, 2002), since ecosystems are necessarily multidisciplinary.

Migrating the concept of ecosystem from ecology to innovation studies shares the same advantages of replacing neo-classical economic models with evolutionary economics theory (Witt 1993; Andersen 1996). Unfortunately, it can also have the same disadvantages, principally validation, lack of active agency and therefore determinism. For Popper (1989) metaphors remain non-falsifiable and therefore cannot be considered as theory. Llewelyn (2002) too differentiates metaphor from theory. However, metaphoric reasoning, Lakoff (1999) argues is a part of scientific method since it can guide emergent understanding and provide the linguistic framework to discuss research results. Determinism is precisely the criticism of biological metaphors in social sciences that Freeman (1992:123) makes, noting the problems that physics envy causes in social science research methods. Like Campbell (1973:54), Freeman accepts the usefulness of biological metaphors, provided they remain grounded in empirical research.

In summary, as Table 2.1 illustrates, metaphors, such as ecosystems, can be theory-constitutive; Ortony (1993) argues, following Polanyi (1958:175), that they create a new framework in which to think and structure evidence.

Characteristic of migrated sub-concept	**Authors**
Dynamic: stability and change	Hodgson (1993)
Learning and feedback loops	Raelin (2008)
Active agency (central unit of analysis is entrepreneur)	Archer (2003); Geels (2004)
Clear boundaries	Stinchcombe (1990) or Stafford Beer (1979)
Justified factors and governance interrelationships between them	Llewelyn (2003)
Scale independent	Pickett *et al (*2002)

Nesting reflects power of factors	Ostrom (2007)
Sustainability with complementary systems	Holling (2001)
Performance can be evaluated	Bateman *et al* (2011)
Different weightings to diverse value outputs	Farber *et al* (2002)
Necessarily multidisciplinary	Nicolson *et al* (2002
Usefulness testable	Draper (1987)
Empirically grounded	Campbell (1973
Relate to culture and context	Shapiro (2011)

Table 2.1: Characteristics of Innovation Systems/Innovation Ecosystems

The epistemological stance in this research on ecosystems is that it is a metaphor that can be grounded empirically (Campbell, 1973) and provides a useful framework with which to think of the wider culture and context facing entrepreneurs. Viewed as a system characterized not by entropy, negentropy or equifinality but rather as an open dynamic system (in Schumpeter's sense), this research regards the innovation ecosystem as useful in Box and Draper's (1987:424) sense that all models are wrong, but some are useful.

2.2 Network of Innovation: An Ecosystem Perspective

In exploring the genealogy of systems thinking, this section argues that it is a wider and less deterministic set of conceptual tools than network thinking and that insisting on active agency suits thinking about innovation in UAE since as a rapidly emerging economy, it is creating a new development pathway. Targeting knowledge-intensive (often service) products, UAE's challenge involves creating the absorptive capacity in basic and applied research to join and exploit international knowledge flows.

2.2.1 Transformation towards Ecosystems

Faced with the remarkable success of Japan's manufacturing from the 1960s onwards, researchers began to investigate Japanese industrial structures, with works such as Womack et al (1990) emphasising the importance of supplier-manufacturer networks and post-partnership networks (Lamming, 1993). Networks have become *de rigour* in business analyses (Häkansson 1982, 1989).

A network is a set of nodes connected by channels; in the case of business and social networks, the channels, governances and goals characterising the network can gain agility from loose ties (Granovetter, 1973), positive externalities and (where there is requisite variety; Grabher's (1993) *wisdom of crowds*. The problem with all social systems thinking (Child, 1984) is that purpose and goals are contested; governances unclear; boundaries ill defined; and causal relationships between actors misunderstood. Where ownership, governances (including leadership), purpose and goals and causal relationships are explicit, shared and stable, then a loose network can become a system (Stinchcombe, 1990) acknowledged by participants and stakeholders (Gallouj *et al* 2013).

The networked structure of innovation can be opaque (Rubalcaba et al, 2013). While there is an extensive literature on innovation networks (Edqvist, 1997; Tuomi, 2002), there are also biases: focusing on technology or market to the exclusion of other factors and agencies (Djellal and Gallouj 2013b; Edqvist, 1997). Importantly, as Moore and Hartley (2008) argue, network analysis focuses on organizations or inter-organizational relations. Schein (1985) makes the point that *organizing* rather than organization is a more fruitful and inclusive way of looking at innovation processes. Additionally, as researchers such as Di Meglio (2013) and Rubalcaba et al (2013) now point out, switching from organization to innovation process as the unit of analysis invites a multiple agency perspective, including individual innovators and entrepreneurs. Post-network analyses of innovation processes also allow for cross-governance studies, including both public and private sector agents (Osborne 2005; 2010; Windrum and Garcia Goñi, 2008; Windrum, 2013), for example in public private infrastructure projects and research projects using university-industry links,

One of the key agents in analyses of innovation has been involving customers or users in co-design. This has a long history and includes Arrow's (1974) learning-by-doing, von Hippel's (1988; 2002) user-led innovation; Rosenberg's (1982) social forces influencing *inside the black box* of technology; MacKenzie and Wajcman's 1985) social shaping thesis; Belkaoui's (1986) learning curve, and Walsh et al's (1992) *winning by design*. Customer shaped co-design features in Cusumano's (1996) analysis of Microsoft's software products and Radnor et al's (2014) idea of service blueprinting; other tools include quality function deployment (Urban 1993; Herrmann et al, 2000).

Research and development (R&D) activities now recognize that customer acceptability is paramount to successful innovation (Alam and Perry, 2002; Edvardsson et al, 2006; Sundbo and Toivonen, 2011). Vargo and Lusch (2004; 2008) summarise this as a switch from a goods-dominant logic towards a service-dominant logic; in the latter of which customer experience and subjective evaluation of products importantly influences success – from technology-push to demand pull (Pavitt 1984; Howells and Wood 1993). Researchers such as Toumi (2002) and Contractor et al (2010) demonstrate the important knowledge contribution customers can make to complex product innovation processes. Viewing innovation as a process open to external ideas (Chesbrough, 2006) from suppliers and customers aligns easily with the multiple perspective approach used in this research. This does not mean that institutional setting is ignored, rather as Lundvall (2007) argues, that a multiple agent, multiple perspective approach to innovation is also a multi-level approach (i.e. 'nesting' multiple and interacting levels of analysis): in my case UAE's national institutions, sectoral capabilities, firm-level activities and individual innovator and entrepreneur initiatives. Linstone's (2010) multiple perspective approach captures this, though with researchers using similar terminology, while such as Heiskanen et al (2009) and Kivisaari et al (2004 & 2013) use the more sociological term societal embedding of innovations.

In summary, business networks, particularly those including critical uncontrolled factors, such as customers/users and business networks oriented towards creating something not yet in existence (an innovation) benefit from an open perspective, such as Linstone's MPT. The challenge, however, remains to construct factors, inter-relationships and boundaries to the system oriented towards success and sustainability i.e. an ecosystem.

2.2.2 Innovation ecosystem governances

One of the reasons Shackle (1972) referred to the *crippled epistemology of economics* was the lack of connection at firm level between economic agency and innovation agency. If economic agency is limited simply to investment decision and then responses to market supply and demand it misses the entire field of governance. Each innovation challenges existing hierarchy and decision-making processes, as Fonseca (2002) argues, calling new governance arrangements into being. For Goodhart (2020) the challenge is whether agents have the head, hand, and heart capable, the absorptive capacity to effectively manage the innovation process. Guyer (2016) points to part of the difficulty in that inherited logics may carry-forward old roles, relationships and responsibilities into the new innovation context. For example, as Toulmin (2003) argues rationality that suited the 'old' arrangements no longer suit the 'new.' Rocha *et al* (2019) give Brazilian examples of the potential new technologies offer being held back by 'old' governance arrangements, whereas in contrast, Zhang *et al* (2019) point to the advantages of the latecomer i.e. flexible governances, being quickly altered in some Chinese companies to accommodate innovated new technological solutions. Van Dijck *et al* (2018) note that if working from established platforms, the innovating company has little choice but to comply with the platform's established governances. Allen and Holing's (2008) work establishes the absence of a central controller in ecosystems, meaning that leadership is often by consciousness raising not command and control of people and resources; this Castells *et al* (2017) is the *new normal* of the ecosystem economy. Mental models that served well with the 'old' product or service, Fowler (2019) spell disaster is carried-forward into a new ecosystem: offering the example of economic contracting (Williamson 1975) as opposed to relational contracting, described by Rajan (2019) as the third pillar (community building) for innovators. In summary, radical innovations always come accompanied by the need for new mental models, new governance arrangements in relation to staff, partners and customers.

2.2.3 Ecosystems in developing economies

The systems approach is applied to business creation and growth in numerous ways. For example, Freeman and Perez's (1988) suggestion that some configurations of institutions more suit innovation has led to national, sectoral and systems of innovation approaches (see Nelson and Rosenberg, 1993; Breschi and Malerba, 1995). Though criticized for lack of active agency Geels (2004), makes the crucial point that in all systems thinking it is important to establish clear system boundaries, causal relations between factors and active agency – particularly leadership and governances (Ogle 2008). In developing economy contexts, it cannot be assumed that institutions have the same degrees of institutional thickness (Amin, 1994) and untraded interdependencies (Storper, 1997) as prevail in developed economies. This is a criticism often made of Etzkowitz's (1983; 2000) triple helix by (See Balzat et al, 2004 & Shapiro, 2011). Similar criticisms may be made of ecosystems as a systems theory. The argument here, however, is (1) the ecosystems approach differs in that an active agent – the innovator – can be made the central unit of analysis and (2) just as in technological leapfrogging (Lee and Lim, 2001) is important, so too in institutional change, absence of inherited structures and sunk costs that benefit rapid change (Easterly, 2002).

One of the ideas explored in this research is that UAE is *not* taking the conventional development path from primary goods to manufacturing. Instead, given its investment capability, it may be possible to make a double leapfrog, directly into high-value services.

Innovators bring innovative solutions (product/service) that are new to their customers (context and market) after evaluating opportunities (Shane, 2004; Shane and Venkataraman, 2000), seeking by meeting a social need to create value, in this case, in the form of profit (Venkataraman, 1997; Sarasvathy, 2001; Sarasvathy and Dew, 2005; Sarasvathy and Venkataraman, 2009). From the perspective of entrepreneurship theory in relation to their own product and competitive solutions to customer needs, they assemble resources and create legitimacy (Shane, 2004) taking the (market, technological or regulatory) risks necessary for success. If deprived of learning opportunities from foreign direct investors (exclusion) or a strong tradition of basic research Audretsch and Thurik (2001), new products are likely to be imitative (though new to target context), re-combinations of mature technologies and/or adapting informal knowledge to the target market. Whilst employees of large organizations may act entrepreneurially, for example leading projects or initiating innovations, their personal risk differs from entrepreneurs starting up businesses.

As Kelley et al (2010:12) notes, in developing economies whilst lifestyle and micro-business innovators are important, innovators building rapidly growing and internationalizing businesses (gazelles) have the greatest multiplier-effect in jobs, GDP, balance of payments, R&D and spawning complementary businesses. These factors are at the heart of Global Entrepreneurship Monitor studies. Gazelle entrepreneur's competitive advantage may result from product, process of business model innovation. As Hatem (2016) shows, emerging market multinationals often flourish by internationalizing into difficult-to-enter markets. Innovators then are learners (Isenberg, 2010), characterized by the emotional strength (Pfister and Böhm) to lead risky ventures (Bell, 1991; Kaplan, 1994) and align the stakeholders necessary to create legitimacy (Rodriguez Pose, 2013; Warwick, 2013).

Numerous authors now cite the ability of innovators in developing economy contexts as a positive aspect of open innovation: these include Isenberg, 2010; Zacharakis et al, 2003; Napier and Hansen, 2011; Malecki, 2011; Kantis and Federico, 2012; and Feld, 2012. Early work by Bruno and Tyebjee (1982) suggests the factors shown in Table 2.2 as constituting an ecosystem supporting innovators.

More recently, Isenberg's (2011) nested approach (innovators, firms, sectors and national institutions) lists ecosystem factors without explaining how they interact; similar points can be made in relation to Volkmann (2009) and Fetters et al (2010) who cite the triple helix as close to ecosystems, though they do not refer to criticisms of the triple helix or its empirical validity. Green et al's (2010) address some of these issues of how factors interact by limiting scope to only university-based ecosystems and Koltai's (2012) work on Ghana limits analysis to six pillars of entrepreneurship and six sets of agents. Stam's (2015:6) insightful reflections on the idea of ecosystem in developing economies (particular the idea of being pulled by value-creation) are useful at a high level of abstraction but less so from the viewpoint of practice.

Venture capital availability	Attractive living conditions
Presence of experienced entrepreneurs	Proximity of universities
Technically skilled labour force	Availability of land or facilities
Accessibility of suppliers	Accessibility to transportation
Accessibility of customers	Receptive population
Favourable governmental policies	Availability of supporting services

Table 2.2: Factors constituting Innovation Ecosystem (Bruno *et al* 1982)

Closest to the position adopted in this research is the work of Mason and Brown (2014) who define ecosystems in terms of agents and processes of high growth businesses, *which formally and informally coalesce to connect, mediate, and govern the performance within the local entrepreneurial environment*. However, the factors their ecosystem includes appear specific to developed economies. For example, spill over effects from university research and large companies are important, especially as talent magnets. Ecosystems they suggest require fertile soil, when our interest is their applicability in infertile contexts.

Just as Porter (1995) includes the importance of *chance*, so too Mason and Brown (2015) suggest that serendipity can importantly influence the success of ecosystems. Serendipity is a *prepared mind*, not luck (Merton and Barber 2004) and as Eisenhardt and Tabrizi (1995) argue, taking advantage of opportunities presumes engaged learning and willingness to change: Chesbrough's (2011) idea of open innovation in *high-velocity environments*.

UAE is such a case: having occupied a pivotal role as a centre of trading and as my introductory chapter shows now with a national vision to become a leading innovation-based economy, a vision shared by innovators and backed by significant oil-based investment resources.

In summary, many researchers envisage ecosystems as a normative list, without nesting, clear boundaries or causal interrelationships between factors. In short, it is an 'approach,' rather than a 'framework' and still less a validated or empirically supported theory. Secondly, its generalizability to developing economies appears limited to those with the resources and determination to privilege internationally competitive innovation. Ecosystems then as a framework appears useful for my research, however, it is important to ground the framework in a set of factors appropriate to UAE growth and for that this research draws upon Linstone's (2010a) multiple perspective theory and its associated toolkit.

2.3 Innovation in the UAE

The great Arab philosopher Avicenna defines knowledge as justified, true, belief capable of being evidenced (Gutas 2014). Since my interest is in commercially exploitable knowledge, this research follows Solow (1994) in acknowledging new knowledge as the *residual factor* explaining rates of economic growth above those predicted by population growth, market expansion and natural endowment. Knowledge from this perspective is a socio-cultural construct; as Vygotsky (1934) argues cognitions in a specific cultural context make sense of new knowledge in the light of old knowledge, language, metaphors, frameworks and emotional attachments. Knowledge for innovation cannot then be reduced to the codification of previous tacit knowledge, as Nonaka and Takeuchi (1995) and Swan and Scarborough (2001) suggest; instead synthesizing knowledge (Gibbons et al 1994) create new (commercialisable) solutions, distributed in the form of products sold at a profit margin.

As Peters (2002) argues, the idea of innovation-based knowledge economies is a hierarchy up which economies move by embedding more advanced knowledge in their products, what Foucault (1991:165) terms *knowledge capital*. Aghion and Howitt's (1998) endogenous growth model predicts that Solow's residual factor and GDP growth closely correlate, subsequently as Carlton (2001) argues, becoming non-rivalrous and non-exclusive. Though Smith (2000) complains that knowledge distribution crystallizes international power relations, the inability of IP laws to prevent generic copying and piracy added to the ability of economies to technologically leapfrog, leaving doors open to emerging economies to overtake previously top economies.
Chang's (2005) argument that IP disarms developing economies by *kicking away the ladder,* has force; however, is evidentially disputed by the rise of Taiwan and South Korea. What is more difficult than technology or knowledge transfer, is mimetic transfer of institutions (DiMaggio and Powell 1983) such as venture capital availability and professional supportive of KBE activity such as accountants, lawyers, designer and marketers: all of which as Florida (1996) and Sassen (2015) characterize an innovation-led development. This research joins Pisano (1997) and Lee (2013) in viewing the shortening of innovation cycles, by narrowing the gap between science and technology (S&T) in emergent sectors, as a key aspect of innovation-led development.

While formal knowledge is transmitted initially in education systems, as Wolf (2002) empirically demonstrates, Galbraith (1979) and others are quite wrong: there is little or no correlation between education and economic growth. Education remains important, especially helping to build the absorptive capacity staff need to participate in international university or business R&D networks: a key source of innovation ideas (Howells and Wood 1993). Levels of education are important *only* if the requisite institutions exist to exploit the resultant absorptive capacity.

Radical or disruptive innovations, especially those dependent on externalities and complementarities, depend on mutual shaping (MacKenzie and Wajcman 1985) by partners and customers. Benefits from basic research are well-known (Rosenberg (1990; Pavitt 1998; Salter and Martin (2001); they have uncertain cost-benefits yet remain crucial to KBEs seeking to stay at the forefront of scientific and technological endeavour. These activities are often combined with teaching and commercialization under the umbrella term university-industry links (UILs; Lecuyer 2006). Deep UILs assist radical innovation, as the Japanese growth experience (Howells 2006) and Silicon Valley's relationship with Stanford demonstrate (O'Shea 2005). Of course, without commercial risk-taking bridging the science/technology gap by taking products to markets, basic research is a costly luxury, as Wu's (2007) study in Shanghai illustrates. Exploiting linkages between universities, business and Government is the core of Etzkowitz (2002, 2003; also, Virasa 2011) triple helix (TH) idea, criticized as relating only to context of deep institutional linkages and not to emerging economies (see Acworth (2008).

The key factor of production for an innovative firm according to Penrose's (1959) resource-based view of firms, is the *cumulative growth of collective knowledge*. Active scanning of the environment is insufficient to cumulate frontier commercial knowledge since without absorptive capacity the firm cannot select and exploit advanced knowledge. Cohen and Levinthal (1989) and Langlois (1997) describe absorptive capacity as learning capability and the possession of cognitive problem-solving skills. For advanced (new solutions) knowledge this means either doing or having access to basic research resulting in both publications *and* patents (Murray and Stern, 2005).

2.3.1 UAE universities and innovation

Successful developing economies build universities capable of basic research are often (in the case of Japan, Korea, Singapore) guided by the state into strategic areas of S&T (Gibbons et al, 1994; Matthews and Hu, 2007). In Japan and now China, UILs often result in state-owned-enterprises, what Micklethwait and Wooldridge (2014) term *state capitalism*. Perhaps a better framework is building on Gerschenkron's (1966) idea of leapfrogging, the idea of a development state (Chalmers, 1982; Johnson, 1982; Woo-

Cummings, 1991) i.e. a national vision for which current generations sacrifice, directed by an elite technocracy.

Abdurakhmanova *et al* (2020) feature UAE as an example of universities transitioning from a teaching to a research orientation. Already, in finance, oil and gas, logistics and medicine, UAE universities are achieving international research level recognition in terms of papers in journals and attracting international research staff and students. Abdelal (2009) makes the point that most emerging economies lack the resources to rapidly build-up university research capabilities, whereas UAE is investing heavily in its universities.

Throughout this discourse the importance of agency has been emphasized: people and their learning and motivation to build businesses. This section briefly considers the profile and motivation of Emirati innovators, leaving a more detailed discussion to the analysis chapters, following interviews with entrepreneurs.

2.3.2 Green innovations

Vidican *et al* (2012) note that UAE (almost ten years ago) already had innovation capacity in the solar energy sector seeking now only to reduce carbon emissions from domestic energy use, but also to provide clean energy in export markets (principally KSA). They identified 44 installation companies and 28 trading companies in the sector with others in up-steam manufacturing and assembly. Masdar is a unique example of a new city expanding with zero emissions (Ibrahim 2018).

Bichai *et al* (2016) surveying water recycling in UAE note Government initiatives to merge companies by offering support to cooperative R&D with the aim (*The National* 2016) of recycling 100% of water used by the end of the decade. Some 50 UAE companies are involved in eco-labelling a service Shabbir *et al* (2020) find that is a growing source of international exports. Dubery (2018) finds that most of UAE's large hotels have joint projects with universities around architectural design to reduce built carbon footprint and economy in carbon usage.

As Chamberlain and Kalaitwi (2020) argue, the point of green (meaning non-carbon) innovations is two-fold. Firstly, UAE in reducing its own emissions will meet its Paris

Environment Accord standards. Secondly, Chamberlain and Kalaitwi argue, non-carbon technologies are one of the key areas in which UAE can create national champions: companies that are not only international (sales, staffing etc) but aiming to become world leading (defined as one of the top-three by sales. Innovation in green technologies is a fundamental part of *Vision 2030* and of this study.

2.3.3 Women Entrepreneurs

To give a flavour beginning with narratives: 40% of Emirati women now work and 70% want to start their own business (Sowmya et al, 2010), with 82% already nurturing a business idea (70% is the international average). These figures are unsurprising given that young women are now 60% of university students and that business support networks for women are growing throughout the Emirates including Al-Moumineen Women’s Association, Khorfakkan Women’s Association; Abu Dhabi Women’s Association (exhibitions, training, links to capital and customers; awards), Dubai Business Women’s Council. Famously Princess Al-Madani (2017) began her fashion label business to inspire other women into business. Al-Maxroule’s (2017) story of starting two innovative businesses, while growing a family is oft-watched and cited. Haan’s (2004) study of home-business Emirati women finds that most are under-40, 75% did business training and are motivated (in order) by money, hobby, gaining experience, planning growth. Almost all have active family support, started with sweat equity and employ an average of five staff, in trade, manufacturing and business service sectors. Ergul and McCrohan (2008) interviewed fifteen Emirati women innovators finding their motivations (in order) were independence, contribution to society, self-improvement and professional development; only 25% mentioned money. Contrary to some expectations, for example Majumdar and Varadarajan (2012), it seems that Emirati women are highly motivated to establish business; noting, however, that few have received support from official business development agencies. UAE is now 26th of the 162 countries on the Gender Inequality Index, with women (for example) surpassing men in many higher education areas. Itani *et al* (2011) and Marmenout *et al* (2014) noted the rising number of women entrepreneurs, which Shaya *et al* (2017) find has risen further. Cultural influences now encourage education and entrepreneurship according to Kemp *et al* (2016), including absence of any legislative barriers and Government sponsored programmes. Madsen (2009) describes these changes as a transformation. We note that women's entrepreneurship remains a major growth opportunity for UAE, one it appears to be grasping and for which we seek evidence in this research.

2.3.4 Private sector growth and company startup rates

As GEM (2016) notes, UAE's TEA rate (early-stage start-up) is like those in Norway and Singapore, with 200,000 SMEs in UAE creating 60% of non-oil GDP. However, there are two big challenges in motivation (Hameed *et al* (2016). Firstly, only 3% of start-ups embed serious technology and therefore have the potential to grow rapidly by internationalization. Secondly, several researchers suggest that particularly young men remain motivated to seek the stability of Government employment (Goby and Erogul (2011); Al-Waqfi and Forstenlechner (2012); and Erogul (2014). This research inquires more deeply into these issues.

Entrepreneurial motivations vary as in all countries. Dubai Entrepreneurs (2017) notes that Vidya Chabbria began running the US$2-billion turnover Jumbo Group when her husband passed away; The National (2017) report that eleven out of thirteen innovators launched their business while working (thus reducing personal risk) and had intrinsic motivation rather than profit, often commitment to a product.

Vision 2030 calls for expansion of existing innovation/entrepreneurship education in schools and universities; see Masri et al (2010) for a somewhat dated report on the success of such education in schools. Similarly, after data gathering the research comments on innovation/entrepreneurship education in universities and commercialization links into UAE Research Centres. Currently, the three-year failure rate is 50% and SMEs are mainly personal services or trading by re-exports.

As Said (2020) notes, the non-carbon private sector is increasingly important in UAE and a source of innovation activity, a factor supported by Sachs *et al* (2007) and Youset *et al's* (2004) longitudinal quantitative study. For example, Al-Gamrh *et al* (2019) study all companies listing on the Dubai Financial Market (DFM) and the Abu Dhabi Securities exchange (ADX) from 2008 to 2012 and finds that the most successful listings are UAE registered companies with high levels of international sales and an international presence on their Boards. Chahine and Tohme's (2009) study of listed companies notes how the Sovereign Wealth Fund, often represented by the Abu Dhabi Investment Authority (ADIA) is often one of the first subscribers to new listings, a clear indication that UAE has no shortage of private sector investment capital and that the *Vision 2030* of diversification is having practical results. Transition from startup to IPO appears to be assisted by the Hawkama Institute for Corporate Governance (HICG), which monitors governance arrangements and provides comfort to international investors in IPOs.

The innovation/entrepreneurial spirit historically characteristic of UAE is alive and well, including (or perhaps especially educated young women). The challenge from a multiple perspective stance, however, is integrating knowledge capture and creation in universities into knowledge-based products capable of high growth levels and from which entirely new products and service can arise.

2.3.5 Public sector support for innovation

Joining the world's elite group of sustainable high-income, innovative economies is a central aim of the UAE, encapsulated in *Vision 2030*. Details of current practices are reported in the Khalifa Fund case study chapter-5. Here we note that unusually for emerging economies, UAE has the wealth to rapidly create a competitive institutional framework for innovation. World Economic Forum *Global Competitiveness Reports* categorise UAE as an innovation-driven economy, meaning that over 30% of GDP results from innovation primarily in finance, tourism, and oil and gas sectors and increasingly from its 200,000 SMEs.

Important developments in recent years include Al Nuaimi *et al* (2019) note systematic use of public procurement to support green innovation. Following work by Godwin *et al* (2006) and Al Nowais *et al* (2016) Al Nuaimi *et al* (2019) detail systematic entrepreneurship education at secondary school and university level. It appears that few Emirati children are not exposed to the mechanics of business startup and inspired by success stories. UAE universities focus on applied research, seek to attract international scholars and are willing partners in international research networks.

There are critical voices. Dubai SME since (2014) and Schiliro (2015) focuses on the low technological innovativeness of SME startups (also El Sokari *et al* 2013 and Al-

Ansari *et al* 2013). Dutot *et al* (2015) contrast UAE with France, pointing to issues such as global champion companies and participation in new product development networks. Hallaimi *et al's* (2013) argues that business discipline in incubation centres should be tightened and Van Horne *et al's* (2011) began a long series of GEM Report responses, principally around internationalisation of SME sales. Many of these issues feature in the case below.

As Jenson *et al* (2016) argues, the UAE Government cannot be accused of downplaying the issue of sustainable economic growth using innovation, it is the implementation that needs deeper understanding and to which this research contributes.

2.3.6 Innovation in Knowledge-Based Economy in UAE

2.3.6.1 Resources and sustainability

Resource endowment has long been understood as a potential curse from the viewpoint of currency value distortion (Krugman, 1987), rentier mentality (Papyrakis and Gerlagh 2004) and plain corruption (Collier, 2008). Auty (2001) and Sachs and Warner (2001) also point to the incentivization of innovation resulting from free or easy cash-flow where resources are abundant. Bjorvantn et al (2012) emphasises that abundant natural resources coupled to rentier incomes reduce start-ups and knowledge-based growth. Interestingly, a contrary position may also be true: the Asian development states (and the Nordics, excepting Norway) are resource-poor and forced into exploiting knowledge. A key issue for UAE then is overcoming this curse of natural resources: using the oil to build diversification channels that create a sustainable innovation-based knowledge economy.

Perhaps the greatest obstacle, Henrekson and Rosenberg (2001) argue, in migrating university research knowledge into saleable technological products is bridging the governances between academia and business. Governances vary considerably between the two in incentives, timeframes, meaningful outputs and the nature of problems researched. One idea to overcome this gap is the academic entrepreneur, defined by Gulbrandsen (2005) as:

> *"Academic entrepreneurs are researchers that have patented their research results, started a new science/technology-based firm or otherwise*

contributed to the commercialisation of research-based ideas and knowledge".

Yet, as Goktepe-Hulten and Mahagaonkar (2009) note, many academics are simply not interested in commercialization and happily delegate it to technology transfer offices (TTOs), sometimes led by people capable of operating in both governances.
The published literature often focuses on patenting (Lam (2010; Ambos, Makela, Birkinshaw and D'Este (2008), whereas, as Pisano (2006) argues for innovators' time-to-market is often a better IP protection, and as Shane (2004) notes less costly and risky.

Two key points flow from considering academic entrepreneurs. Firstly, building on Dasgupta and David (1987) question; "*are academic researchers and entrepreneurs incentivized to exploit research knowledge?".* This poses complex issues of how to incentivize academics: money, time, or prestige? Secondly, if TTOs are part of the answer (as agents or managers of incubation centres), research shows that academic management of commercialization often fails to effectively bridge governances (Stankiewicz 1998; Dahlstrand 1999; Albert et al, 2002; Dahlstrand and Klofsten, 2003). The question then for UAE is "*are TTOs and university-linked incubators managed by businesspeople and supported by the UILs likely to help successful commercialization?* These questions relate to the 'white space' separating the component parts of Linstone's TOPs: how the Technical, Organizational and Personal inter-relate with each other. Further justification of choosing Linstone's multiple perspectives theory and why not other theories is discussed in the next chapter.

2.4 Ecosystem Factors

Table 2.3 lists 43 factors relevant to UAE's innovation ecosystem taken from the above literature reviews; in each case referencing the literature and indicating critical areas of factor activity - factors in an ecosystem are continuously interacting and therefore changing. Human agents interpreting the meaning of factors interactions often initiate such change in the case of complex agent systems such as an innovation ecosystem.

The factors discerned from previous research are distributed between the five levels of scaling: (1) the KF, (2) firms, (3) relevant SSIs, (4) UAE organisations and institutions and (5) GCC institutions and international standards, trends and institutions. In each case, Linstone's TOP toolkit is used to further categorise the factors. Chapter 3 clarifies the meaning of each factor in terms of its *function* within the UAE ecosystem structures and what *activity and actions* result might result from the factor, following which the factors are distilled further under four *activity* headings. Activity is stressed because the ecosystem is self-sustaining because of activity responding to changed activity by factors. One criticisms of some ecosystem theory (such as Holland 2014) is that it downgrades agency by portraying factors as simply functional within a structure i.e. their reaction to other factors is linear and predictable. This is not the case, since in human systems (unlike physical systems) there are *always choices* of responses to changes in other factors. Here the meaning of each factor is clarified.

Table 2.3. demonstrates the researcher's interpretations of the key factors published in the literature and match these factors with the participants background, including policy makers, KF's staff and Start-up owners (innovators). This table also sheds the light on the importance of the interactivity occurring between these factors of innovation ecosystem.

Incubation, (F3; F5; F7; F8; F14; F21; F26; F27), can be a disciplined process (time-limited, business planning) guided by a business mentor and drawing upon work-based learning in companies relevant to the product. Undisciplined time and effort in incubation may simply shield innovators from the challenges of market exposure, as Pisano (2006) suggests.

Venture capital (VC), (F3; F12; F13F31; F35), is expensive because it risks today's resource against a future income stream without asset security. VCs (Bell 1995) invariably want to control the business plan and business leadership; they also need a firm exit plan: all these provisos can challenge the innovators perceptions of growing a company.

Scaling levels		Factors	Derivation from literature	Key areas of interactivity
Khalifa Fund				
	F1	Online presence + tools	Gallouj (1997) model	Innovator/entrepreneur
	F2	Links to UILs/SSIs/Firms	Etzkowitz (2003)	Entrepreneur/technical R&D
	F3	Fund and partners	Harrison (2008)	Links present risk/future gain
	F4	Linkages to MoU agencies	KF Gateway	Builds business network
	F5	Business led incubation facilities	Isenberg (2014)	From idea to product
	F6	Business support staff	KF Gateway	Time/market and risk reduction
	F7	Links to firms and mentors	Goldstein (2012)	Rapid learning from experience
Firms				

	F8	Proof of concept support	Bell (1991)	Links present to future
	F9	Market entry and growth	Mason & Brown (2015)	Market and its potential
	F10	Product and its R&D	Chesbrough (2012)	Open innovation ideas
	F11	Process technology	Kelley et al (2010)	Align with market trajectory
	F12	Risk capital access/structures/exit	Harrison (1992)	Risk and future income stream
	F13	Leverage, bank facilities	IMF (2015)	Options if banks risk-averse
	FI4	Costs and their control	Easterly (2002)	Customers and market
	FI5	Supply + logistics	Davidson (2009)	Supply hub and value chains
	FI6	Leadership	Ogle (2008)	Visionaries and ideas space
	FI7	Staff and partners	Geels (2004)	Knowledge flows/networks
	FI8	Useful knowledge flows	Sterman (2002)	Linking S&T: new products
	FI9	Education standards/ staff training	Solow (1956)	Competences/capabilities
	F20	Reputational capital	Mokyr (1990)	Legitimacy-building; trust
	F21	Business professionals (inside firm)	Windrum & Goñi (2008)	Consulting expert opinions
	F22	Business mentors	Goldstein (2012)	Business advice/role models
3-SSIs				
	F23	UILs, company R&D links	Etzkowitz (2003)	Exploit basic/radical research
	F24	Media representation	Porter (1995)	Positive imagery/symbolism
	F25	Big company learning	Geels and Schot (2007)	Using knowledge spillovers
	F26	Business mentors	Goldstein (2012)	Mimetic process innovation
	F27	Business networks, customer voice	Shane 2004; Vargo 2004	User-led innovation
	F28	Entrepreneurs' Legitimacy	Mason (2014)	Exploit network connections
	F29	Business professionals (in SSI)	Di Vries (2006)	Business professionals supply
UAE/GCC				
	F30	ICT infrastructure	Castells and Hall (1994)	Enables innovating
	F31	Regulations: IP, Tax	Sassen (2006)	Certainties midst uncertainties
	F32	Logistics infrastructure	Baumol (2012)	Using services value chains
	F33	Rule of law/no corruption	Collier 2008)	Crucial to internationalisation
	F34	Policies: grants, business friendly	Martin (2010)	State/region competition
	F35	Exit market	Sassen (2006)	Essential for VC to flourish
	F36	Effective labour markets	(B-Savenius (2016)	Overcoming skill shortages
	F37	Open expert migration	Gladwell (2006)	Export challenges for SMEs
International				
	F38	Clear international standards	Gordon (2015)	Standards a qualifier condition
	F39	Routes to connectivity	Isenberg (2014)	Entering global networks
	F40	Complementarities	Holling (2001)	Joining technology platforms
	F41	Inward FDI learning opportunities	Audretsch (2001)	Learning from spill overs
	F42	Involved in R&D networks	Todeva (2013)	Getting on inside of R&D
	F43	Staff with absorptive capacity	Casper (2007)	Competition for key staff

Table 2.3: UAE innovation ecosystem factors

International knowledge networks, (F4; F18; F23; F25; F27; F37; F38; F39; F42), are particularly important for knowledge-based innovation and any future innovation-stream. Without absorptive capacity, entry into company or university knowledge networks is difficult, costly and without benefit; establishing legitimacy, as Howells (2012) notes, is always a key challenge.

Staff capable of innovating, (F16; F17; F18; F28; F36; F43), links to membership of international knowledge networks and to evolving products, while rushing to market with the first set of products. Why rush? Initial failure is often the result of under-capitalisation resulting from lower-than predicted earnings or higher costs. The innovative SME must produce and research simultaneously.

Local networks for big company learning, (F2; F4; F7; F17; F18; F23; F22; F25; F39), as Mathews (2002) argues, can create learning, and recruitment and sales opportunities. Where *psychic distance* is great (for example because of foreign language and culture), learning from big companies can require considerable investment of time and effort, for example tooling or R&D simply to meet supplier qualifier conditions.

Mentoring, (F5; F7; F21; F26) as Goldstein (2012) points out, can be a rapid, low-cost learning curve, especially for complex processes such as internationalisation or regulatory compliances. Interacting with experiences businesspersons unlocks tacit learning and builds network connections.

Professional's knowledge, as Sassens (2006) notes, developed economies cluster the business professional's knowledge-based companies need. F4; F5; F21; F29 highlight the benefits and necessity of this exposure in a developing economy context and (in thin institutions) their limited availability. Where professionals are available the new firm may have to invest considerably to access their knowledge.

Standards, (F19; F21; F28; F43), and complementarities (F12; F28; F38; F40) are critical to knowledge-based SMEs who cannot expect to alter existing norms (unless their product is a radical disruption). The ecosystem entrant such as the biopreneurs, apppreneurs, and ecopreneurs must maximise complementarity and comply with standards as quickly as possible.

In summary, this section has selected forty-three factors, in each case referencing the literature and indicating how the factor interacts with the other parts of the ecosystem. It has explained the nature of some factors, highlighting dilemmas (trilemmas?) facing innovators. Chapter-3 returns to these factors in constructing a new framework with ontological insight from Linstone's multiple perspectives theory and tailoring to the UAE context.

2.5 Research Gaps

The below Table 2.4 summarizes thirteen gaps in existing literature identified in the literature review and how this research will respond to them (Nicholson *et al's* 2018 revelatory contribution): by filling eleven of the gaps and contributing ideas and new empirical data to two gaps (1 and 6) the scope of which is beyond robust conclusions from this research. It is anticipated that for five of the gaps mentioned in Table 2.4 the contribution will be empirical (1, 2, 6, 12, and 13) and in eight cases the research will make a theoretical contribution, from which it is anticipated that journal papers will be published; these gaps are: 3, 4, 5, 7, 8, 9, 10 and 11 in Table 2.4.

Chapter 1 introduced UAE and the challenge of diversifying into a knowledge-based economy as an alternative to oil-dependency, justifying using Linstone's (2010) multiple-perspective approach, seeking to achieve a holistic analysis of UAE's innovation system, focusing on three target technologies: life-sciences, non-carbon and software.

To summarize, having argued for a non-linear wide (socio-technical) perspective on ecosystems in Chapter 2, taking account of context and culture to avoid technological determinism, drawing attention to the importance of active (learning) agency in innovation processes and the potentially disincentivizing nature for innovation of rich resource endowment, such as oil. The chapter has argued that innovation and entrepreneurial activity are inseparable, centrally featuring active agent learning and are shaped significantly by context and culture. The UAE innovation ecosystem was defined in terms of shortened cycles between science and its exploitation as commercial technology, noting the importance of basic and radical research in creating the absorptive capacity necessary to join international knowledge networks and to develop products capable of internationalization.

The innovation ecosystem therefore requires deep UILs, long-term research investment and inclusion in international research networking. It is notable that the profile and motivation of Emirati innovators is under-researched, in particular the propensity of young people to launch knowledge-based new businesses.

	Gap in literature	My contribution
1	Insufficient empirical research on UAE entrepreneurship in particular issues of young entrepreneurs and university spinouts and associated questions of IP, risk capital, exit routes	• Contribute towards filling
2	No study and analysis of Khalifa Fund and its contribution to *Vision 2030*	• To fill this gap
3	No systematic analysis (Al-Naqeeb) of UAE's strategy for achieving knowledge-based economy status	• To fill this gap
4	No analytical framework specifically designed for economies with UAE characteristics (high-investment resources, mid-range industrial structure) noting Linstone's (1996) mismatch theory i.e. how social institutions and technological capability align; additionally, Skok and Tahir's (2010) suggested gap in research on Gulf cultures and context in building a modern economy.	• To fill this gap
5	No systematic analysis of the difficulty in applying Etzkowitz's (2008) Triple Helix to a rapidly developing economy such as UAE	• To fill this gap
6	As section 3.1 below points out, MPT has yet to be applied to a context of a rich developing economy such as UAE, with leapfrogging capability, posing issues for what scaling and TOPs will be relevant and how these might differ from convention (poorer) developing economies.	• Contribute towards filling
7	Agency and physical ecosystem theories are sometimes conflated, resulting in determinism. My work will clearly feature active agency as an essential characteristic of UAE's innovation ecosystem	• To fill this gap
8	Section 2.1 argues that innovation and entrepreneurship inseparably link implying that envisioning ecosystems as simply creating technological novelty is inadequate; instead, an E&I ecosystem necessarily contains agents supporting entrepreneurial activities.	• My research adopts this holistic perspective
9	Section 2.3 highlights the importance of focusing on new learning process instead of the management of exiting knowledge making active learning and risk-taking agency an essential part of an E&I ecosystem and calling attention to UILs, education standards and the absorptive capacity of staff all of which connect with Government interventions. The gap here is conceptualising ecosystems sufficiently broadly to include these factors.	• My research creates a holistic framework encompassing these factors
10	Noting the disincentivising effect on entrepreneurship or resource richness, section 2.3 suggests this is a gap needing further research.	• To fill this gap
11	Section 2.3 argues that shortening the science-technology gap critically involves understanding governance clashes with the UIL triangle, issues that previous research has neglected in developing economies.	• To fill this gap
12	The profile and motivation of UAE entrepreneurs is an under-researched area (section 2.3)	• To fill this gap
13	UAE's sectoral innovation systems (perhaps apart from oil) are under-research as section 2.1 illustrates, in particular building SSIs in knowledge-based sectors that effectively link with international knowledge networks.	• To fill this gap

Table 2.4: Literature gaps from my literature review (updating Tables 1.4)

Also, under-researched in the nature of State involvement in creating UILs, in particular in the three sectors that this research targets from the perspective of the KF's engagement in UAE's innovation ecosystem. The chapter concluded by selecting forty-three factors for ecosystems identified in my literature reviews, classified using Linstone's TOP toolkit, noting that the following chapter 3 will use these in creating a new analytical framework. Finally, Table-2.4 lists thirteen gaps in research literature, indicating those to which my research contributes theoretically and empirically.

Conclusion

Reflecting on scaling and noting Von Krogh and Roos' (1995) point about self-sustaining interacting successfully between levels of scaling, it is now clear that this research's framework will operate on the five levels of scaling shown in Table 2.5.

This research disagrees with Holland's (2014) suggestion that complex (industrial) agent systems can be represented as directed networks since networks have agreed goals, leaders and governances, whereas the nature of ecosystem emergence is the absence of central control: learning responds to events and opportunities by each agent's adaptation resulting in new cross-over rules, new *edges* (fan-outs) and restructured panarchies (Holling et al, 2008).

Scaling level	Why necessary for analysis	Key areas of interactivity
Khalifa fund	The 'core' of the ecosystem resourced to grow life-science, non-carbon and software businesses	Firms, university and large company research networks, Government agencies, risk capital funds, companies capable of mentoring
Firms	The firms supported by the Khalifa Fund and their internationalisation growth trajectory	Product markets, other high-growth firms in target sectors, knowledge networks, Khalifa Fund, SSIs and supporting Agencies
SSIs supporting 3 target technologies in in UAE & GCC	Controlled and led SSIs supporting key value flows: capital, market access, knowledge, staffing and UILs	Khalifa Fund and firms in sector + specific network and Government initiatives, regulations, standards affecting the sectors and absorptive capacity
UAE/GCC institutions, markets	Institutions such as IP, exit markets, tax, company law and major strategic investments	Governments, agencies, international agencies, standards and markets, including staff mobility and UIL research and connections with large competition R&D
International connectivity	Product markets, skills, knowledge flows, capital markets and private/public knowledge networks	Markets and agents, capital markets, knowledge flows (especially large firm R&D networks and university projects)

Table 2.5: Scaling levels necessary for MPT UAE ecosystem framework

It is the continuous interaction between agents across scales that disturbs ecosystems and results in sustainability from mutual adaptation. From the firms' viewpoint this takes the form of emergences in legitimacy and resource marshalling. For the KF and SSIs assessing firms and their growth opportunities, disturbance changes how pull and push factors are coupled. At the level of UAE institutions disturbance and adaptation within the ecosystem poses the challenge of reforming institutions, as always referencing Lewis (2014) the invisible cultural differences that are important to businesses. Finally, for international connectivity as new emergences occur in international markets and knowledge flows, so strategies and connections will evolve, bearing in mind always Isenberg's (2011) point that national ecosystems vary in response to cultural heritage and opportunities. Discussion now turns to using MPT and TOP to put content into innovation and entrepreneurship in UAE by examining the context of the Khalifa fund.

Having reviewed previous literature relevant to an innovation-based economy (table-2.3, indemnifying gaps in the literature (table-2.4) and the context and culture facing UAE (objective 4, the thesis now turns to creating a conceptual model of an innovation-led economy, in the following chapter meeting objectives 1 and 2 of the research (section-1.3).

CHAPTER THREE: THEORETICAL FRAMEWORK

Introduction

Following the definition of key research gaps and research problems. This chapter reviews relevant theoretical instruments to build a framework that fills the research gap and answers the key research question, meeting objectives 2 and 4 as set out in section-1.3. The chapter reviews candidate theories and models of innovation that have been highly cited in the previously published research and that could offer partial (not in full) answer for the main research question. These lenses offer a systemic view of the innovation ecosystem and helps understanding the nature of innovation knowledge than to employ innovation resources. The advantages and disadvantage of each theory/model have been addressed to offer a convincible audit of why the multiple perspectives theory (MTP) theory was preferred over these models/theories of innovation ecosystems.

The third section reviews the MTP theory and justify why it has been selected as a theoretical lens for this research. Then, the 43 factors pointed out in chapter have been redefined in terms of the Technical, Organisational, and Political. These three perspectives reflect different Kantian perspectives. The first, ***Technical***, reflects the people's view of causality and resource-based view of innovation. The second, ***Organisational***, reflects the social construction of institutions that are involved in the innovation ecosystem and the people's average consensus on value and routines. The third, ***Personal***, reflects the self-ego view of people who have vested interest and political motives behind innovation.

3.1 Alternative Theoretical Lenses of Innovation Ecosystems

This section critically evaluates five alternative lenses (models and theories) that was frequently used in the literature to address the phenomenon of knowledge-based innovation ecosystem. The discussion in this section does not aim to put these lenses in order rather than to address their qualities for the present research, this includes actor network theory (ANT) (Callon, 1980), the national innovation systems (NIS) (Lundvall, 1992); the sectoral systems of innovation (SSIs), Triple Helix model (TH) (Etzkowitz, 1983) and the Foresight (and scenario planning) perspective (Martin, 2010). Since each of these approaches makes use of the idea of 'logics.' This review begins by discussing logics and agency.

3.1.1 Logic model

As Patton (2011) notes, systems and ecosystems frameworks are not predictive models, instead they posit outcomes from factors, which once causal relationships are established may migrate into models. There is then an implied 'logic' in the ecosystem's framework privileging desired outcomes (Gertler et al, 2011; Technopolis group and Mioir, 2012). This logic may be summative (overall outcomes) or formative, which as Scriven (1991) suggests means the factors (such as policies) are open to change, as are initial key success factors (Rip, 2003). From the viewpoint of this research, evaluating inputs and outputs while important, is not as problematic as analysing change (transformation) processes as Chen (2005) and Dyehouse et al (2009) note without visibility inside processes and logics it is impossible to provide an evidence-based programme of change. Research shows that revealing the logics of why and how particular processes fail or succeed is the most difficult aspect of analysing ecosystems (Smith, 2000; Arnold, 2004; Edqvist 2005; Patton, 2010; and Ahrweiler, 2011). As Arnold (2004) and Kuhlmann et al (2010) note, before logics or patterning of processes can be verified the researcher needs dig deeply into events and decisions (including paths not travelled). This is an advantage of the TOPs toolkit accompanying MPT, as will now be demonstrated as lacking in Logic model.

3.1.2 Actor network theory

ANT is a sociological theory developed by Callon (1980, 1986) and Law and Hassard (1999) the purpose of which is to analyse the social shaping of technology by stressing contingency and the heterogeneity of techno-economic networks which result in new technologies, for example in Bijker and Law (1992). It avoids the danger of deterministic 'logics' in simple systems theories by ascribing agency to *actants* in dynamic interactions with each other, purporting not to privilege particular outcomes. ANT has two problems from the perspective of this research i.e. analysing what, how and why processes of UAE's prospects. Firstly, it is a post-facto framework explaining an evolved process (such as the bicycles, doors, nuclear waste) but incapable of forward analysis. Secondly, the researcher is concerned that ANT ascribes agency to inanimate objects (non-people) that clearly cannot make conscious choices. ANT's strength (Latour 1987; Misa 1992) is interpretative flexibility its weakness and inappropriateness for my purpose as Sørensen and Levold (1992) are rooted in its sociological origins, when my research requires an economic policy and business framework.

3.1.3 The Triple Helix

An obvious approach to include as one of Linstone's over-arching multiple perspectives is Etzkowitz's (1983) triple helix (TH) a neo-institutional framework designed to map and analyse the inter-relationships between Government, universities and business that commercialise university research building a knowledge-based economy. Each TH triad is a sub-system (Luhmann 1984), evolving together to support commercialisation (Leydesdorff 1996; 2008; Leydesdorff and Etzkowitz, 1996, 1998); the idea of an entrepreneurial university is important: educating and researching to meet the needs of industry and adopting a *third mission* to commercialise. This research argues that in relation to UAE, TH may be useful as a metaphor for knowledge-based development; however, it is fatally flawed as a conceptual framework applicable to an emerging economy and society such as UAE.

While originally (mode-1) TH theory emphasised the key role of the state (Turpin et al, 1993; Leydersdoff and van den Basselaar, 1998; Shinn, 2002; Etzkowitz and De Mello, 2003), a later (mode-2) version, Etzkowitz (2003) places more emphasis on universities and business. TH suggests five processes: technology transfer, collaboration and conflict moderation, collaborative leadership, substitution, and networking in three *spaces*: knowledge, innovation and consensus; what Todeva and Etzkowitz (2013) term a *highly charged intellectual enterprise,* with knowledge and learning centre staged. Researchers have suggested various improvements to TH theory: Arnkil et al (2010) who add users making a quadruple helix; Lindberg et al (2010) add a gender dimension; MacGregor (2010) frame TH as an eco-system and Datta and Saad (2011) including international migration using collaborative learning. Gan *et al* (2010) reach the unsurprising (if disheartening) conclusion that success breeds success: their study of

Chinese Provinces shows that technology transfer occurs most successfully in those Provinces already at high levels of capability.

Compagnucci *et al* (2020) note as an innovation platform LLs featuring cross-disciplinary expertise are particularly suited sustainability challenges as Bakıcı *et al* (2013) found. Purcell *et al* (2019) argue that LLs can form a link between bottom-up and top-down innovation initiatives. They are a form of collective governance designed to support experimentation, especially social innovations in urban areas, according to Voytenko *et al* (2016), where Van Geenhuizen (2019) they can rapidly respond to service user needs and suggestions. Like TH, Levenda (2019) argues LLs are meant to facilitate transition of knowledge into technology by fast-forwarding usability and ethical issues a result of cross-disciplinary proximity.

According to Audretsch and Belitski (2021) adding the third 'leg' of commercialisation to universities previous research and teaching functions was a result of the Bayh-Dole Act (1980) which consigned intellectual property rights (IPR) based on federally funded research to the initiators of the research (individual and organisations) and not the Federal Government. Thus, universities were incentivised to exploit knowledge created, with the welcome consequence of reducing state aid (Audretsch 2007) and encouraging spillover activity (Audretsch 2014) partnering with businesses. For Guerrero and Urbano (2012) TH commercialisation aligns knowledge capital and commercial capital. Universities doing basic and advanced applied research benefit most according to Baglieri *et al* (2018) and Fuller *et al* (2019) with Stanford in the US being the prime case. Cunningham *et al* (2019) refer to these changes as the *entrepreneurial university*, others are less sanguine and regret setting research priorities around commercial interests. Miller *et al* (2014, 2018) argues forcefully that the TH perspective provides a clear social role for universities. Brekke (2021) however notes that regions with the best research universities benefit most from TH activity and Hayter (2015) that while many universities strive for the TH model, some find parts of it difficult to achieve, for example, business interactivity in depressed regions. While Chadran *et al* (2020) note how long the lead-time is for universities to move up the 'ladder' of research capability. While Mowery *et al* (2001) speculated that university basic research would suffer from private sector sponsorship, a view echoed by Aksoy *et al* (2020), Isaacson's (2021) work on R-DNA coding and the speed at which Covid inoculations were designed, suggests otherwise. As we note below, the TH gives rise to tensions in universities, for example, when non-academic business managers oversee academic research work (Leitner *et al* 2021), or (Dai *et al* 2019) there is political interference in universities. As Lehmann *et al* (2021) and Leitner *et al* (2021) argue, academics insisting on a role in nascent businesses can be problematic.

Fundamental aspects of TH theory remain unresolved. For example, Deakin (2014) notes an absence of informal social networks, so important in Silicon Valley (Massey and Quintas 1992). Single case supportive studies of TH abound in South America alone, these include Mello and Rocha (2004); Etzkowitz, Mello and Almeida (2005); Saenz (2008); Bianco and Viscardi (2008) and Luna and Tirtido (2008). More recent quantitative studies using TH such as Isaksson et al (2016) fall back on US patent data and Bartels et al (2016) study of Ghanaian knowledge competences. However, without a robust theoretical base, researcher's variables make studies non-comparative. Other empirical studies find little support for the interactions proposed in TH theory including Farmer et al (2016); Vaivode (2015); Zaini et al (2015); Inzelt (2015); Balzer and Askonas (2016). Reich-Graefe (2016) for example, finds that hybrid legal entities become more important than 'official' institutions.

Theoretically, TH theory is criticised for underplaying the importance of governances (Tuunainen 2002), especially since as Vohora et al (2004) shifting between academic and business governances is a major obstacle to commercialisation and few universities incubators are led by people with business experience (Kirkland and Stackhouse 2011). TH theory fails to address the central issues of entrepreneurship i.e. legitimacy and resource assembly. How to overcome Stinchcombe's (1965) *liability of newness* and generally according to Saad (2004) is theory-lite, failing to integrate with other bodies of literature. Etzkowitz (2008) simply adds-on new ideas without interrogating contradictions; for example, adding knowledge-capital without addressing Fine and Fine's (2001) critique of what constitutes capital. Leydesdorff and Ivanova (2020) criticise the assumption that academic researchers will act as flexibly as private sector researchers in choosing projects.

Fernandes *et al's* twenty-five-year review of TH in practice drew favourable conclusions finding that they bring the public and private sectors together and more rapidly disseminate knowledge. Also positive, Simon *et al* (2019) found that TH-conceptualised innovation, for example in accelerators or incubation centres, bring business monitoring and risk-capital investors closer to product development, introducing business criterion earlier in product development cycles. Lindhult *et al's study* (2021) finds TH especially suited to areas where formal and informal knowledge meet, for example applying artificial intelligence to new local public service solutions involving AI-experts and service users. Many of the critiques of AI systems in O'Neill (2014) and Eubanks (2018) would not have occurred had a TH mindset been applied in innovation processes, which would have resolved user difficulties at design stage.

Several researchers argue that the TH model works especially well in Asia's emerging economies with Toan (2021) arguing that the centrality of the State to economic development means all agents respond to their call for cooperative working: Toan provides examples from Vietnam, which is supported by Thi Bich Hanh Tran and Anh Dung Vu's (2021) study of 37 universities, 91 managers also in Vietnam. They argue that whereas Chinese universities maximise patent applications, universities in Vietnam focus more on spinout businesses. Perumal and Sreekumaran Nair's (2020) study of TH in India presents a nuanced case of non-elite universities accumulating patents, with few successful spinouts, while elite universities, such as the Indian Institute for Technology in Bangalore on a par with US universities for close business links and successful spinout activity.

Yang's (2021) study in China, makes the interesting point that TH activity around environmental improvement are only successful if they construct a wide constituency of interests (including political interests, such as Provincial Governments). Research elsewhere supports this conclusion, for example Oliver *et al* (2020) call attention to extended-TH in environmental projects, Zhang *et al* (2019) to broadly based TH initiatives in the construction industry and Meng (2020) to value-chain based TH initiatives in advanced manufacturing.

While university-industry links are critically important in deepening a knowledge-based economy, authors such as Balzat and Hanusch (2004) note how difficult it is to use the TH framework in developing economies since it is precisely the emergence (under-development) of institutions that defines countries as *developing* (Shapiro 2011). TH as Whetten (2009:31) argues frames a problem (commercialisation) without suggesting any deep theoretical framework or policy agenda to resolve it. TH as a heuristic: useful despite its theoretical shallowness and difficulty migrating to the developing economy context.

In summary, there are mixed conclusions from the use of TH initiatives in emerging economies, disputes that in relation to UAE only new empirical work will resolve.

3.1.4 National Innovation Systems

NIS theory aims to explain the differences between economies in technological achievement from a viewpoint critical of classical comparative advantage theory. Freeman and Perez (1988) suggested the NIS approach, as a socially rooted explanation of differential technological adaptation and economic growth, applying at the level of the state. Freeman and Perez (1986) were concerned to offer an alternative explanation to that of cultural particularism. Various researchers have suggested factors constituting NISs Lundvall (1992), Porter (1990) and Rosenberg (1992) Nelson and Rosenberg (1993) and Edquist (1997) being important. While it seems clear that some institutional settings are more favourable to innovation and growth than others, NIS theorists cannot agree on which institutions are important.

Carlsson and Stankiewicz (1995) point out that the theory can fail to move between institutional levels (national to sector or region): a failure of analytical scaling. Studies of east-Asian innovations (Huang 2008; Choi and Zhou 2010) point out that institutional arrangements quite different from those in the west can be successful. Lack of a robust set of institutions, clear linkages between nested levels of analysis and a contestation over policy proposals leads me to reject NIS as an analytical framework for my research.

3.1.5 Sectoral systems of innovation

The Dutch transition management approach to sectoral systems of innovation (SSIs) is based on the work of Rip and Kemp 1998), Kemp et al (2001), Geels (2002); Kemp and Rotmans (2004); Kemp and Loorbach (2006) and emphasises untraded inter-dependencies giving leverage to managed sectors. These include economies of scope and knowledge spill overs operating at the level of a social landscape, sectoral regime and niche innovators (Geels and Schot, 2007). Geels (2004) envisages firms breaking out of niche size into international competitiveness when exogenous circumstances are favourable to exploiting the knowledge and absorptive capacity they have embedded in marketable technologies. These circumstances may as Hall and Soskice (2001) and Casper (2007) point out, simply be favourable regulatory change.

The strength of SSIs is the synthesising of social and technical aspects of innovation within a broad sectoral setting. However, its weakness includes (a) the passivity of waiting for exogenous change rather than building new markets, (b) the possibility of negative lock-in to clever technologies without commercial prospects, (c) as Breschi and Malerba (1995) argue, some SSI analyses are merely descriptive and do not offer an analysis of actions to take creating success. As Scott (1995) notes, governances in technological systems enable or disable success, SSI theory says little about conflicts, competition for resources and sectoral governances what Kay (2004) refers to as *disciplined pluralism*. These are especially important if locally successful firms are to internationalise, Gladwell's 2006) *phase transitions* requiring new sectoral governances and re-focusing of resources. Most importantly, (e) SSIs fail to connect with what Ogle (2008) terms *ideas space* i.e. the cognisant individual innovator and entrepreneur creating a new solution for customers, SSIs focus on knowledge management not individual learning sparking creating new solutions.

A current adaptation of SSI is the idea of smart cities, exemplified by Masdar, the *smart city in the desert* UAE project. Esashika *et al* (2020) emphasise using the latest ICTs and populated by knowledge workers as constituting a smart city. Wang (2019) accepts this; however, his view of smartness is intense oligopolistic competition between clustered companies in international markets, with cooperative new product R&D projects in the home smart city base. For Zhang *et al* (2019) the smart city has the latecomer flexible structures advantage with the possibility of rapid adoption of emerging technologies. Pan *et al* (2018) draw attention to the potential symbiosis proximity offers especially when cross-governance working (companies and universities) requires trust building. Perez-Luno *et al* (2017) would undoubtedly agree, emphasising as they do tacit knowledge flows in smart cities. Sennett's (2018) critique of smart cities is precisely that dwelling and using transport systems that keep people apart is un-smart and that the smart city may not have the latest transport and communications systems, while it may encourage knowledge networking: he cites the cities of Paris and London as centres of innovation, while slow and old in other respects.

Notwithstanding the limitation of SSI approach as an analytical tool we include their use later as part of UAE's innovation ecosystem since, the SSI approach is a useful descriptor of what exists and since it remains the case that clustering of firms and (physical and intellectual) infrastructure provide fertile ground for sectorally-focused innovations.

3.1.6 Foresight Approach

Linstone's MPT is a foresight tool. From the perspective of this research rather than being considered as an alternative frame, the foresight readily accommodates MPT. Foresight (Martin, 2010) aims to understand as Coates (1996) suggests, *the forces that shape the futures in the long term* to inform policy and resource distribution, what Godet (1986) terms *la prospective*. Whereas forecasting extrapolates a probable future, foresight emphasises alternative futures (Martin and Irvine 1989; Martin 2010) and sits more easily with the multiple perspective framework as Dyehouse et al (2009) Kuhlmann et al (1999), Kuhlmann (2003) and Williams and Imam (2007) successful argue. For example, Georghiou et al (2008); Kuhlmann et al (1999); and Kuhlmann 2003) point to the opportunities arising from foresight to redistribute resources to potentially successful technological areas and speed up diffusion within sectors or clusters using dynamic modelling (Cabrera et al, 2008; Sterman, 2000) based on participative input of active agents such as policymakers and innovators (Kivisaari et al, 2004, 2013 and Rotmans and Loorbach, 2009).

Foresight aims to influence future development so that it better meets those long-term societal needs characterised by the increasing complexity and faster cycles (Martin and

Johnston 1999; Toivonen 2004). It does this using prospective analysis i.e. systematically understanding of potential future directions and forces to shape them (Martin and Irvine, 1989; Martin, 2010; Miles, 2013) and then evaluating uncertainties and anticipating long-term decision consequences and social acceptability (Ahlqvist et al, 2012; Bell, 2003; Havas et al, 2010). This participatory approach seeks to identify consensual perspectives grounded in practicality (Dufva and Ahlqvist, 2014; Godet 1986; Kivisaari et al, 2013; Martin and Irvine, 1989; Martin, 2010). As Auvinen et al (2014) and Dufva (2015) insist, foresight must then route-map the decision processes by which actual strategic decisions can be taken. Foresight aligns closely with Linstone's TOPs tools in that technology is not singled out as a predominant factor; instead, opportunities and technology are given equal weight.

Foresight has been used extensively in preparing long-term innovation strategies in (for example) United Kingdom, Australia and New Zealand (Georghiou et al, 2008; Martin and Johnston, 1999). It operates best at multiple levels of capacity and capability building (Becker, 2002; Dufva, 2015; Rohrbeck, 2011, Saritas, 2013) as an over-arching multiple perspective (innovator/firm, sector and national economy) in this research.

This study of the UAE, with its vision of a leading innovation society, is of high importance due to the potential of attraction, creation and exploitation of knowledge, figuring prominently in the country foresight studies cited above. From the viewpoint of this research, situating knowledge flows within a foresight-TOPs approach and an over-arching multiple perspective framework, supports the research to drawing from scenario building, road mapping and trend analysis from policy documents and previous research. Like Martin and Irvine (1989), Holopainen and Toivonen (2012) and Popper (2008) this research particularly draws on Ansoff's (1975; 1984) idea of *weak signals*: emerging technology and business model ideas (in the UAE case within the software, non-carbon and life-science sectors) that represent the first indicators of new product waves – propitious new ideas that can become market leaders (Wygant and Markley 1988). As Phaal et al (2003) point out, *picking winners* is not a science and invariably blends quantifiable trends (Coates, 1996), with qualitative judgement (instinct, intuition) as noted by Georghiou et al (2008). Having innovation in UAE as a specific unit of analysis helps, since as Toivonen (2004) argues, the concern here is not with foresight in general, but rather foresight that aligns with the capabilities and capacities of UAE. In this sense, cross-referencing with TOPs grounds foresight in the reality of UAE. This research therefore proposes to use Linstone's multiple perspective framework and TOPs approach, drawing also on foresight tools and analysis. As Managers, policymakers and other stakeholders are interviewed, the research will be cross-referenced (as Havas, 2007) recommends. Non-confirmatory, conflicting or complementary visions and assessments, as Eerola and Jørgensen (2008) and Dufva and Ahlqvist's (2014) studies each show, are as valuable as confirmatory evidence. Additionally, shifting between (for example) firm and incubation centre manager levels then to policy makers, as Martin (2010) notes allows both a bottom-up and top-down foresight. Miles' (1999) study of services is one of the few concentrating on non-physical goods sectors. This research envisages targeting the three sectors mentioned as identifying both goods and services as relevant to UAE's future.

In summary, this section has argued that alternative frameworks to MPT are less appropriate to this research, highlighting what Nicholson *et al* (2018) term revelatory conclusions – gaps and inadequacies in previous literature. The section has argued that the logics model is a useful descriptor of past processes, whereas this research is creating a framework with which to help guide future actions. Secondly, that ANT is also post-facto and ascribes agency to non-cognitive agents, thus disabling emergence. While TH theory remains useful as a metaphor for knowledge-based commercialisation, this section has argued that in assuming mature and deep institutions and inter-relationships the approach negates the very problem being researched here.

There are concepts in NIS and SSI approaches that are found useful such as Geel's (2004) *ideas space*, however, both approaches are more descriptive than analytical, exemplified by their lack of policy agenda. Finally, this review has argued that MPT sits easily with the foresight approach, since both look to understand the future by analysing the present: MPT is a type of foresight approach.

This discussion does however point to gaps in MPT, and how it applies to an oil-rich developing state such as UAE. These gaps include what precise scaling is appropriate to UAE's innovation future and precisely what content is appropriate in terms of applying TOPs to UAE. These gaps will be addressed in this research. Since internationalised services are likely to feature prominently in my three chosen sectors (non-carbon, software and life-sciences), this review now turns to consider innovation in services and how it differs from innovation in tangible products.

3.2 Multiple Perspective Theory

In section 1.2, Linstone's work, for example (1981) and (2010a) was cited as a motivation for my research. Avoiding repetition, here this research focuses on how Linstone's work is used and built upon, rather than restating his multi-perspective theory (MPT). In doing so, we show how later researchers have developed Linstone's ideas, including the work of Fevolden (2015), Bigliardi *et al* (2015), Galati *et al* 2016), Kim (2017), Strasser (2018) and De Valerio *et al* (2020).

Similarly, eclectic approaches to analysis are adopted in other areas of business research. For example, Dunning's (1977; 1988; 1995 and 2000) theory of international trade draws in a range of network, technology and global strategy framework. Linstone's multiple perspective begs the question: what multiple perspectives? By way of analogy, MPT is a soup bowl, into which soup goes – the soup in this case, this research argues, is his own TOPs approach and other proven approaches relevant to the research questions. The argument is that MPT provides an over-arching framework for this research, which will extensively draw upon the TOP tools Linstone recommends. Unpacking MPT and TOPs tools will also make use of the additional theoretical constructs discussed below. This overcomes Avison and Wood-Harper's (1991) implied critique of Linstone that MPT is bereft of practical tools and connection with social theory; noting in passing that Avison et al's suggested tools are simple consultancy models for information systems consultancy work. Section 3.1 (following) argues that within an over-arching MPT framework, using TOP tools a new framework for understanding innovation in a developing economy context can be constructed. In addition, this research employs as relevant to innovation in UAE the foresight approach, refers to Madu and Jacob's (1991) ideas on cognitive mapping and later ideas on learning and strategic decision-making tools (such as Zhu (1999) and stakeholder intentions (Metcalfe and Hobson (2001). This research gives more emphasis than Linstone to the culture and context of UAE, though it can be noted that he too does this in grounded research (2008). Galati *et al* (2016) in researching commercialisation also note the lengthy timespan and reach into context and culture of the TOPS approach:

essentially it is an open system of innovation. For reasons explained in section 3.1, this research makes little use of NIS and Triple Helix theory, except as metaphors. Methodologically, the research argues that Linstone's approach is robust, however, it will also be argued for the use of Charmaz's constructed grounded theory (and associated qualitative analysis tools) and only carefully employ the notion of logics.

The use of multiple perspectives is justified by Linstone (1989) who comments that "*each perspective yields insights not obtainable from the others*" and that the "*O (operational) and P (personal) perspectives are essential in bridging the gap between analysis and action*" (1989:314). Thus, O and P perspectives are used to complement the T (technical) perspective, not to replace it. Using the O and P perspectives allows us to bring in the human and social factors that are replete with complex problems and thus focus on human beings both as individuals and groups, including ethical analysis (Wood-Harper et al., 1996). In addition, Linstone (2002:292) states that "*any perspective may illuminate any element* and *it is conceivable that a technical element can be understood without use of the technical perspective"*. Fevolden's (2015) research on single and multi-use of computers is entirely based on Linstone's approach capturing multiple interactions, multiple levels or multiple type of computer use. Therefore, making use of different perspectives in this way allows concentration more on how we look at a problem rather than on what we are looking at.

Though Pradhan (2002) and Mercier-Laurent (2011) recommend ecosystems as an analytical approach using a multiple perspective, in both cases their emphasis is on the technical aspects of innovation. This research differs in two important ways. Firstly, like Linstone, the current research sees the socio-cultural environment in which an innovation occurs as important, not only to the shape of innovations, but also to its social and market success. The analysis of UAE here is therefore wider than those of Pradhan or Mercier-Laurent. Secondly, but associated with this last point on market success, the analysis here of UAE views entrepreneurship as a necessary associate of successful innovation. Clearly, it is possible for an entrepreneur to successfully launch a new product that is merely novelty or re-packaging and not an innovative new solution to customer's problems. However, the innovator must herself, and in partnership with others, act entrepreneurially to successfully take an innovation to market. Like Strasser (2018) who developed a ranking system for use with Linstone's Delphic Panel approach, we too use Delphic panels in the form of senior managers of the Khalifa Fund commenting on the results of our survey and interview conclusions.

Having clarified the non-linear, emergences nature of ecosystems based on their complexity and justified my choice of Linstone's (2010) MPT as a way of constructing a framework for innovation in UAE, this research now turns to considering what might be alternative choices of frameworks, using this to critically evaluate Linstone's approach.

This chapter puts content into Linstone's (2010) Multiple Perspective Theory (MPT) approach suggesting a complete list of factors for a framework with which to analyse the United Arab Emirates' (UAE's) pathways for the *2030 Vision*, focusing on the Khalifa Fund's (KF) role and three target technologies: life-science, non-carbon and software. Throughout the chapter refers to Linstone's Technical, Organisational and Personal (TOP) toolkit highlighting the ways in which factors interact to create an innovation ecosystem. Table 3.1 indicates (in no order of priority) some of the key conceptual approaches and concepts featuring in this literature review.

Key conceptual approaches featuring in analysis	**Authors**	**Key concepts featuring in analysis**	**Authors**
Social learning	Vygotsky (1934); Ilyenkov (2020)	TOP categories	Linstone (2011)
Multiple perspectives theory	Linstone (2009); Fevolden (2015)	Innovation	Freeman (1982); Galati *et al* (2016); Strasser (2018)
Complexity theory	Holland (2015)	Thick institutions	Amin (1994)
Constructed grounded theory	Charmaz (2006; 2019)	Triple Helix	Etzkowitz (1983)
Active Agency	Archer (2009): Schatzki (2019)	Resource marshalling	Sarasvathy and Venkataraman 2009
Ecosystem theory	Holling (2001); Oliver *et al* (2020)	Sectoral systems of innovation	Geels (2002); Yang *et al* (2021)
Open innovation	Chesbrough (2012)	Scaling	Von Krogh and Roos (1995)
Globalisation velocity	Isenberg (2014); Smith (2021)	National innovation systems	Nelson and Rosenberg 1993
Knowledge spill over and commercialisation	Audretsch (2001); Jones *et al* (2020); Audretsch and Belitski (2021)	Customer orientation	Easterly (2002); Van Geenhuizen (2019

Table 3.1: Selected key approaches and concepts found in literature review

Taking an out-to-in perspective, the chapter begins with clarifications and issues from previous research and then locates the KF within the UAE innovation ecosystem, with a clearly defined set of factors could be approached from numerous angles. Since the research purpose is make contributions in (a) research contribution and (b) practical management it has adopted *Occam's Razor* approach and limited the scope of the chapter to the minimum. This means neglecting interesting areas such as cross-cultural studies, the dynamics of new cultural service products (Florida 2005), emerging identities in the UAE, new spatial geography and the emerging geography of risk capital.

3.2.1 Multiple Perspectives of Innovation Ecosystem

As indicated in section-1.2, the thesis employs Linstone's Multiple Perspective Theory as an over-arching, deploying his *Technical, Organisational and Personal* (TOP) toolkit as a means of classifying factors in UAE's innovation ecosystem; as shown in Table 3.2 below. An essential feature of ecosystems, as opposed to networks, is that continuous interactions and learned change create self-sustainability. Bigliardi *et al* (2015) find that TOP enabling commercialisation in Italy, building ecosystems using MPT to demonstrate multivariant knowledge flows. As these changes or emergences occur, Holland (2014) makes clear such interactivity is between agents, between scales, at system edges (and fanouts) and may be consequence of abrupt discontinuities resulting from exogenous shocks (Barro, 1997; Holling et al, 2008). Since ecosystems have no central controller, their analysis relies upon detecting patterns of emergences i.e. causal relationships. Vecchiato and Rovenda (2009) show how foresight can be deployed in long-term strategy making citing EU and US company cases.

The purpose of this chapter is to distil the forty-three factors and their principal interactivities shown in Table 3.1 into a more manageable initial framework; *initial* in Charmaz's (2006) sense of a speculated framework based on the literature that is used to structure data gathering and analysis and is subsequently revised into Framework-2 i.e. altered to take not of actual patterns and factor interactions observed and analysed empirically. Framework-2 will thus be a contribution to theory: the hypothesised framework-1 having been tested against practice. From the viewpoint of Linstone's approach, this chapter fleshes-out which multiple perspectives are appropriate for answering my research questions around UAE's innovation system. This is like De Valerio *et al 's* (2020) technology road-mapping, especially new forms of management and their effect on project success. Using three variables (main component, eigenvector centrality, and closeness centrality) Kim's (2017) study plots the whole network of a Korean semiconductor company, showing that position in network correlates with innovativeness. We now take four similar steps: (1) distilling (with justifications) the factors into a more manageable - composite, thematic – number: (2) conceptualising the factors (within the UAE innovation system boundaries as an analytical framework; (3) demonstrating how the new framework will work in practice; and (4) justifying the framework as superior to alternatives. These four steps structure this chapter, followed by conclusions and a stock-taking before moving to method, data and analysis. We note with Konnola *et al* (2009) that the design and management of technical foresighting projects can limit digression, uncertainty and ambiguity arguing that effect project scoping is the key variable.

3.2.2 Typology of Innovation factors based on TOP

Scaling levels		Factors	Derivation from literature (S-section)	Key areas of interactivity
Khalifa Fund				
Technical	F1	Online presence + tools	Gallouj (1997) model	Innovator/entrepreneur
	F2	Links to UILs/SSIs/Firms	Etzkowitz (2003)	Entrepreneur/technical R&D
Organisational	F3	Fund and partners	Harrison (2008)	Links present risk/future gain
	F4	Linkages to MoU agencies	KF Gateway	Builds business network
	F5	Business led incubation faciliti	Isenberg (2014)	From idea to product
Personal	F6	Business support staff	KF Gateway	Time/market and risk reduction
	F7	Links to firms and mentors	Goldstein (2012)	Rapid learning from experience
Firms				
Technical	F8	Proof of concept support	Bell (1991)	Links present to future
	F9	Market entry and growth	Mason & Brown (2015)	Market and its potential
	F10	Product and its R&D	Chesbrough (2012)	Open innovation ideas
Organisational	F11	Process technology	Kelley et al (2010)	Align with market trajectory
	F12	Risk capital access/structures/e	Harrison (1992)	Risk and future income stream
	F13	Leverage, bank facilities	IMF (2015)	Options if banks risk-averse
	FI4	Costs and their control	Easterly (2002)	Customers and market
	FI5	Supply + logistics	Davidson (2009)	Supply hub and value chains
Personal	FI6	Leadership	Ogle (2008)	Visionaries and ideas space
	FI7	Staff and partners	Geels (2004)	Knowledge flows/networks
	FI8	Useful knowledge flows	Sterman (2002)	Linking S&T: new products
	FI9	Education standards/ staff training	Solow (1956)	Competences/capabilities
	F20	Reputational capital	Mokyr (1990)	Legitimacy-building; trust
	F21	Business professionals (inside firm)	Windrum & Goñi (2008)	Consulting expert opinions
	F22	Business mentors	Goldstein (2012)	Business advice/role models
SSIs				
Technical	F23	UILs, company R&D links	Etzkowitz (2003)	Exploit basic/radical research
	F24	Media representation	Porter (1995)	Positive imagery/symbolism
	F25	Big company learning	Geels and Schot (2007)	Using knowledge spillovers
Organisational	F26	Business mentors	Goldstein (2012)	Mimetic process innovation
	F27	Business networks, customer voice	Shane 2004; Vargo 2004	User-led innovation
Personal	F28	Entrepreneurs' Legitimacy	Mason (2014)	Exploit network connections
	F29	Business professionals (in SSI)	Di Vries (2006)	Business professionals supply
UAE/GCC				
Technical	F30	ICT infrastructure	Castells and Hall (1994)	Enables innovating
	F31	Regulations: IP, Tax	Sassen (2006)	Certainties midst uncertainties
	F32	Logistics infrastructure	Baumol (2012)	Using services value chains
Organisational	F33	Rule of law/no corruption	Collier 2008)	Crucial to internationalisation
	F34	Policies: grants, business frien	Martin (2010)	State/region competition
	F35	Exit market	Sassen (2006)	Essential for VC to flourish
Personal	F36	Effective labour markets	(B-Savenius (2016)	Overcoming skill shortages
	F37	Open expert migration	Gladwell (2006)	Export challenges for SMEs
International				
Technical	F38	Clear international standards	Gordon (2015)	Standards a qualifier condition
	F39	Routes to connectivity	Isenberg (2014)	Entering global networks
Organisational	F40	Complementarities	Holling (2001)	Joining technology platforms
	F41	Inward FDI learning opportuni	Audretsch (2001)	Learning from spillovers

Personal	F42	Involved in R&D networks	Todeva (2013)	Getting on inside of R&D
	F43	Staff with absorptive capacity	Casper (2007)	Competition for key staff

Table 3.2: UAE innovation ecosystem factors based on TOP

Taken from the literature review, Table 3.1 lists forty-three factors, in each case giving examples of their interactivity within an innovation ecosystem. Where these themes arising in data coding, the methods literature advises a process of reflection aimed at reducing the number to a manageable four or six (Bryman and Bell, 2012 for example).

Factor from research	Function in innovation ecosystem (ES)	Possible activity when other factors change
F1: Online presence + tools	ES provides problem-solving	Business planning
F2: Links to UILs/SSIs/Firms	Communications platform	Network building – legitimacy
F3: Fund and partners	Helps marshal resources	Access resources (funds)
F4: Linkages to MoU agencies	Ready-made network	Network building – legitimacy
F5: Business led incubation facilities	Practical help and support	Innovator refines product idea
F5: Business support staff	Practical help and support	Innovator learns about business
F7: Links to firms and mentors	Store of embedded knowledge	Innovator learning
F8: Proof of concept support	Practical product development	Legitimised product idea
F9: Market entry and growth	Signposts/pathways to market	Legitimated sales
F10: Product and its R&D	Continuous product refinement	Product alters with customers
F11: Process technology	Productivity improvements	Learning to reduce costs
F12: Risk capital access/structures/exit	Investment cycle benefits all	Firm marshal’s start-up/growth resourc
F13: Leverage, bank facilities	Provides working capital	Bank leverages firm’s capital
F14: Costs and their control	Diffusion of cost-saving ideas	Entrepreneur can reduce process costs
F15: Supply + logistics	Supply-function externalities	Ready-make logistics lower cost/risks
F16: Leadership	Entrepreneur legitimised in ecosystem	Entrepreneur’s decisions build firms
F17: Staff and partners	Pool of staff/partners in system	Recruitment/partnering made easier
F18: Useful knowledge flows	System distributes learning	Entrepreneur learns and benefits
F19: Education standards/ staff training	Strong pool of human capital	Staff capable of innovating/growing
F20: Reputational capital	Trust: reduced transaction costs	Deepening partnerships
F21: Business professionals	Pool of embedded knowledge/capability	Firms learns/uses expertise/wisdom
F22: Business mentors	Transmission of informal learning	Entrepreneurial learning at lower cost
F23: UILs, company R&D links	Links science to technological products	New (potentially disruptive) learning
F24: Media representation	High social/self-esteem of entrepreneurs	Innovator legitimate
F25: Big company learning	Distribution of spill over learning	Learn best practice for global markets
F26: Business mentors	Transmit learning/bond entrepreneurs	Free social/knowledge capital
F27: Business networks, customer voic	Grounds product with market/customers	Ideas for user/market-led innovation
F28: Entrepreneurs’ Legitimacy	Network-effect from more members	Benefits from trust/transaction costs
F29: Business professionals	Options for make/buy expertise	Lower start-up/growth costs
F30: ICT infrastructure	Proprietary inclusive systems	Easy communications and searches
F31: Regulations: IP, Tax	Clear rules-of-the-game	Planning easier with certainties
F32: Logistics infrastructure	Cluster-benefits: service specialisation	Shape services to meet needs/options
F33: Rule of law/no corruption	Stability	Legitimacy within legal framework
F34: Policies: grants, business friendly	Stability and assistance	Access free cashflow + support
F35: Exit market	Recycles investment funds	Recapture control of business
F36: Effective labour markets	Pool of potential (qualified) staff	Flexible: hours/jobs/workplace
F37: Open expert migration	Internationally mobile labour available	Hire + transfer absorptive capacity/
F38: Clear international standards	Ecosystem a compliant partner	Eases international market access
F39: Routes to connectivity	Ecosystem can fill/create gaps	Ready-made (costly) network available
F40: Complementarities	Ecosystem has place in value-chains	Ease of future-proof designs
F41: Inward FDI learning opportunities	Transfer technology, knowledge, capital	Knowledge flows: learn from the best
F42: Involved in R&D networks	Acceptability in international networks	Join co-design of tomorrow’s products
F43: Staff with absorptive capacity	Pool of top-level talent	Buy-in absorptive capacity/expertise

Table 3.3: Functions in ecosystem structure and possible activities of factors

Following this path and seeking to distil down the factors is problematic since distillation cannot triangulate between literature and findings: the research has yet to achieve empirical findings. Instead, following (Bryman and Bell) Table-3.3 revisits the Table 3.1 lists of factors, in this case examining their function and activity with an innovation ecosystem, based on what the literature has revealed and my own sense as a practitioner for ten years how innovations occur. Following this reflection, the factors have been distilled/amalgamated into thematic/composite sets for inclusion in the analytical framework.

Privileging function and activity in Table-3.3 and subsequent classifications requires justification. Douglas (1987) frames the issues of understanding individual agency within organisations as one of acknowledging the tension between institutions or organisations that bestow sameness (1987:63) in which cognitive individuals aspire to differentiate themselves. Ethnographic studies overcome the determinism of functionalism not by ignoring functions, but as Czarniawska-Joerges (1992) suggests by grounding the individual action or story in a specific (subnet) context; rejecting as Burawoy (2010) recommends *pseudo universalism* in favour of what Garfinkel terms *situational rationality*. In relation to the factors, Table-3.3 therefore captures function (role and relationship to rest of system) and activity (what agent may choose to do and what it may mean within a system context). Peltonen (2007) follows a similar path and Archer (2004) similarly introduces ambiguity into relating the function (prescribed) to (un-prescribed) activities. Privileging function and activity then capturing the objective and subjective aspects of the factors.

Several factors from the literature appear twice in Tables 3.1 and 4.1 since at times the literature refers to (for example) mentors, logistics or professionals either from the demand side (from the firm or entrepreneur's viewpoint) or from the supply-side (from the institutional or ecosystem's viewpoint). Merging these seemingly duplicated factors in another reason for distilling them. Reflecting on the factors in Table-3.3 and their functions and *potential* activities the four groups of factors shown in Table-3.4 emerge. Haegeman *et al's* (2012) important editorial remains us that future-orientation in technology gives competitive advantage and in allowing careful long-term strategic planning allows companies to assemble the capabilities and capacities giving time-advantage in innovation processes.

Of course, these groupings are not hermetically sealed, especially when taken between the five scales at which ecosystem interact. At issue is more whether the groupings are conceptually useful for understanding ecosystems. This exercise grouped the factors using Linstone's TOP toolkit only then realising that differentiation is at a much higher level of abstraction since these factors are extracted from research literature focused on a specific structure and activity (i.e. the innovation ecosystem). This is evidenced by the fact that the four-grouping suggested each include agency – they are each potential activity, whereas TOPs is a more generic function descriptor.

Thematic groups of factors	Factors	Meaning
Entrepreneur/ innovator (agent)	Factors: 5 6 8 10 11 16 27 30 31 32 33 38	Innovator/innovation/entrepreneur i.e. the agent as active innovator
Legitimacy	Factors: 1 4 9 15 20 24 28 35	Legitimacy: the firm/agent/product normative acceptability by other agents and by institutions/organisations as compliant i.e. suitable to do business with; an invisible asset that reduces transaction costs and generates trust
Marshalled resources	Factors: 3 12 13 14 17 34 36 37	Resources and their marshalling behind a business idea (what Schattschneider [1975] terms the *mobilisation of bias*) i.e. the financial, technical and people resources necessary to launch and grow a business
Knowledge flow	Factors: 2 7 18 19 21 22 23 25 26 29 39 40 41 42 43	Knowledge flow i.e. purposive learning and distribution of learning by key agents migrating science into (saleable) technology and its continuous redesign and process improvement at a profit margin

Table 3.4: Condensed categorisation of ecosystem factors

To be clear, active agency is important to understanding how ecosystems flourish; there are always alternative pathways and choices. Choice implies cognition and emotional commitment, like the activity system at the centre of Vygotsky's (1934) learning *zone of proximal development*. This is not to imply a great-man-theory-of-business i.e. the lone innovator featured in shallow accounts of celebrity businesspeople. Instead, active agency here suggests teams of innovators and entrepreneurs coming together to build a product/business and similarly (though with different terminology) an SSI or Government and like De Valerio *et al's* (2020) technology road-mapping.

Having espoused concerns about functional representations of social structures being open to determinism, it remains the case that functions are important: within structures (such as the five scales of an ecosystem) functional categories covering Technical, Organisational, and personal are the scaffolding or skeleton in which relationalities of active agency occur in innovation, legitimacy, resourcing and knowledge flows. This view is reinforced by the successful use of Linstone's approach by researchers such as Vecchiato and Rovenda (2009) and Kim (2017). In summary, having trawled literature on innovation ecosystems and identified forty-three relevant factors (Nicholson *et al's* 2018 consolidatory conclusions), it is possible decompose their meaning by considering functions and activity and in doing so to posit four thematic classes of factors.

3.3 Adopted Theoretical Framework

Although an ecosystem has no central controller, this does not mean it has no central influences. Interactivity amongst factors and with key active agents is one such central driver creating relationalities and fanouts at system edges that can change ecosystem membership. However, these are dispersed activities. In complex social ecosystems learning is a shared attribute as Arthur (2015) notes. To be clear, this is not a collective consciousness, since cognition is always individual and only then distributed (and not by telepathy). Nor is this *wisdom of crowds* (Surowiecki, 2004) since that relates to resolving a single problem not a multiplicity over ongoing time periods. Learning in ecosystems is an act by cognisant humans, while the activity itself can be said to be central to the sustainability of the ecosystem. Note that one implication of this for ecosystem analysis is that unlike algorithmic models there are no simple predictions or forecasting. Ecosystem analysis, like agent-based economics (Holland 1991; Arthur 1994) depends on active and ongoing engagement with learning and learning distribution processes within the system. Where this not the case then certainty over the future of ecosystems would replace uncertainty and events such as the 2008 crisis or into which start-up to invest, would be predictable. Citing Jackson von Krogh and Roos (1995:36) and Jackson (2011), Linstone agrees that clear conceptual levels of scaling and interaction between levels is an essential feature of MPTs. In figure-3.1, factors are placed towards those levels of scaling found in both Holland (1991) and Linstone's work and the framework contribution to which Nicholson *et al* (2018) draw attention.

Simple pictorial representing the forty-three factors of ecosystems derived from the literature review (figure 3.1) reveals a jumbled picture of the ecosystem, rather than an analytically useful schematic representation. It is based around the condensed categories of factor: this is shown in figure 3.2, which can now be justified as framework-1 (to be amended in chapter-7 following analysis of new empirical data).

Archer’s (2004) point is noted: that institutional theory must explain two things, (summarised as stability and change) i.e. how do norms, rules and culture result in cultures and structures the predisposition agents to particular judgements and actions and secondly, what conflicts and contradictions are inherent in the institutions the explain changes of institutions, when they occur; points returned to below.

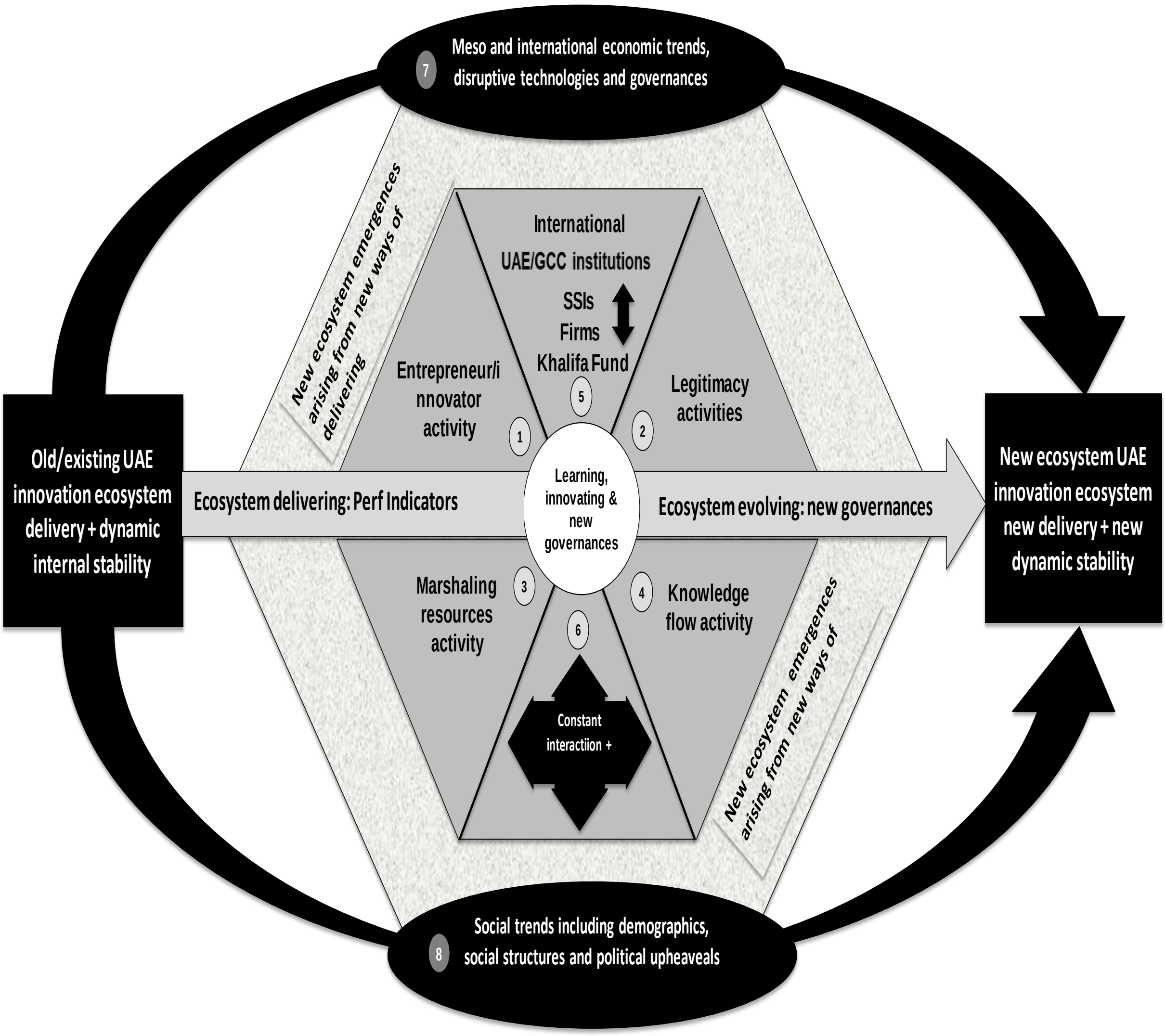


Figure 3.1: Framework-1 representation of UAE’s innovation ecosystem

The dark-grey hexagon towards the centre of figure 3.1 represents the existing ecosystem; it supports company formation and growth with interacting ecosystem factors numbered [1], [2], [3] and [4]. These operate over five levels of scaling shown in [5], with the black arrow indicating interaction across levels of scaling and in [6] between factors and in fanouts at the edge-boundaries of the ecosystem. As interactions create new emergences, these either cumulate into a new ecosystem or because of abrupt discontinuities (internally or externally triggered) create a qualitatively new ecosystem, shown by the outer hexagon.

Shifting from an old or existing ecosystem to a new ecosystem, is shown in the arrow crossing the hexagons to be arise from the system delivering performance factors such as company start-ups, company growth and innovations. As patterns of new governances, systems members and interactions emerge, a new ecosystem comes into being. New systems may also be triggered by exogenous trends and events, shows by the dark arrows [7] and [8] or alternatively these global institutions may for a time support and strengthen the existing constituted ecosystem. An arrow pointing northeast from the existing ecosystem shows that patterned change in this and other ecosystems can over time reconstitute powerful global institutions, which are themselves social constructions and therefore changeable. Finally, at the very centre of the ecosystem is the circle of learning, innovating and new governances. This is the point from which active agent learning results in innovations, which are always accompanied by new governances. Active learning and its enactment by way of innovations and new governances explain *both* stability and change in the ecosystem. Learning enables the ecosystem to deliver (for examples) start-ups, company growth and new products; also, learning drives the patterned changes of interactions and activities that eventually create a new ecosystem.

An ecosystem framework needs to elucidate both (degrees of) stability and (degrees of) change. Ecosystems are never stable, constant interaction between factors is precisely what creates adaptation and self-sustainment. Figure-3.1 inner hexagon contains in condensed form, the forty-three factors identified from the literature allowing an innovation ecosystem to innovate sustainably.

Significant exogenous change may be accommodated within an existing ecosystem. For example, each of our three target technologies has seen recent important changes. Software is no longer autonomously created instead software-as-a-system techniques add customised elements on to ‘core’ programmes.

A software ecosystem may be able to adopt this new technology within existing arrangements, or it may not (for example if programmers lack competences). Non-carbon products have radically altered as lithium battery technology has advanced, power storage improved, and micro-generation diffused. Again, a non-carbon ecosystem may adapt or be completely disrupted by these technological changes. Life-science technologies such as stem cells and genetic engineering are displacing pharmaceutical solutions: can the ecosystem adapt and benefit or has it been insular to such changes and its existence is now threatened? The point is that an ecosystem may be open to new technologies, even new general-purpose technologies, or relatively closed: determining whether the ecosystem can adapt as presently constituted or needs to reconstitute (a new ecosystem) or demises, following the Swiss mechanical watches, and non-Internet mobile devices into the pages of history.

For ecosystems the great uncertainty are major external events. Scheidel (2017) identifies four possibilities: mass warfare, transformative revolution, state failure and lethal pandemics. The stability and ability to adapt of many ecosystems would be challenged by any of these events. Chance and serendipity too can be important. Visionary leaders, (such as Sheikh Zayed bin Sultan Al Nahyan, Sean Lemas, Lee Kuan Yew or Deng Xi-Ping), may or may not emerge. China leads electric vehicle battery innovation in part because of the chance of having 75% of world lithium deposits. In short, chance matters for ecosystem vitality or demise.

This framework and the summary of literature in table-3.2 (condensed in table-3.4) meet research objectives two and four as set down in section-1.3 above.

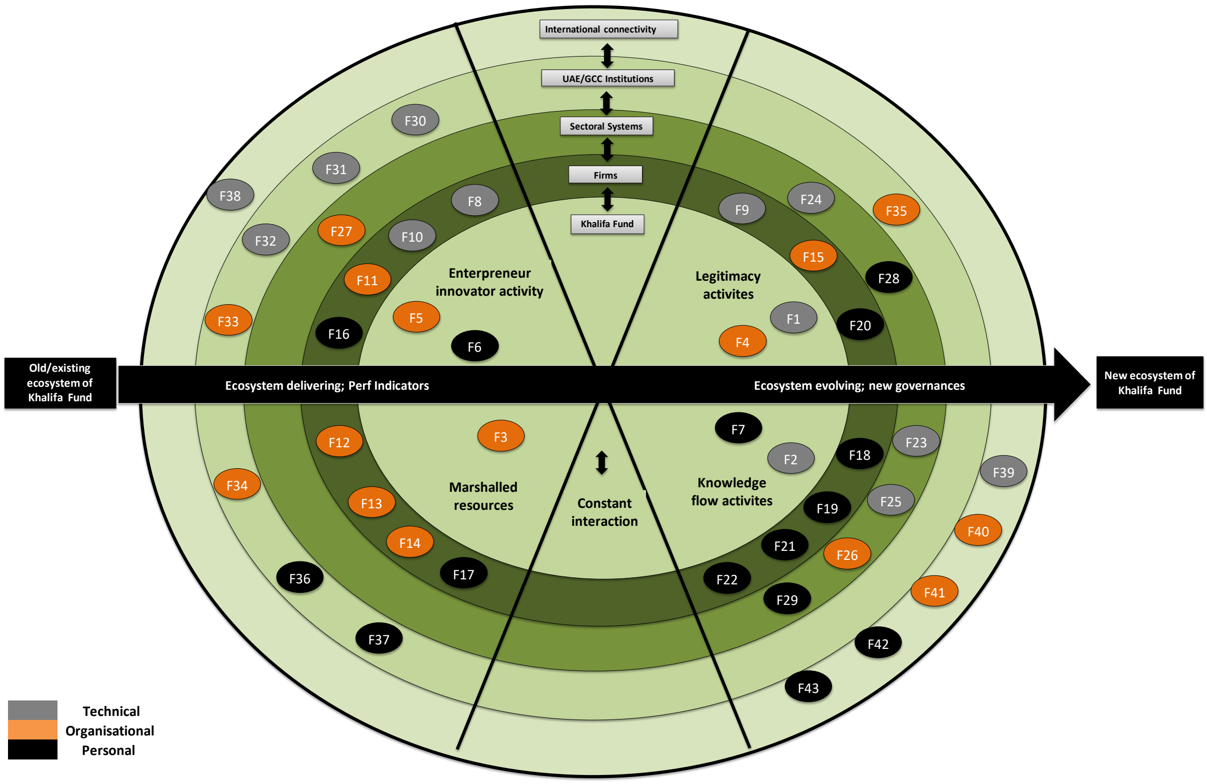


Figure 3.2: Showing the 43 factors from literature review

The factors in figure-3.2 are categorised by (TOP) technology, operation and people, nested in five levels of scaling and representing a shift from and old to a new ecosystem resulting from learning and innovating

In summary, figure 3.2 represents a framework-1 of UAE's innovation ecosystem, based upon factors identified in the literature review and previous research on complex innovation ecosystems. categorised by (TOP) technology, operation and people nested in five levels of scaling and representing a shift from and old to a new ecosystem resulting from learning and innovating

3.3.1 Operationalisation of Theoretical Framework

Kundera (1984) notes, the world has *the intoxicating relativity of human things* complexities irreducible to the simplistic and wrong psychological assumptions that have led Economics and associated science into a blind alley, where its most fundamental theory (the efficient market hypothesis) is now rejected (Colander, 1992) as ergodic. Summarising the behavioural alternative, Bookstaber's (2017) agent-based economics invites analysts to map agents, their behaviour and learning patterns and only then to forecast. Figure 3.2 can be used similarly beginning with conventional ‘factual’ performance indicators (PIs), (see the Table 3.5 example) and then compiling a ‘still’ picture mapping agent relationalities and causalities. From patterns of emergences over time a ‘moving’ picture materialises.

Khalifa Fund factors			**Qualitative Performance Indicators**	**Quantitative Performance Indicators**
Technical	F1	Online presence + tools	Use of toolkit, quality of online site	Presence online and toolkit
	F2	Links to UILs/SSIs/Firms	Quality of interactivities	Evidence of interactivities
Organisational	F4	Linkages to MoU agencies	Importance/quality of MoUs	Numbers/evidence of MoUs
	F5	Business led incubation facilities	Output from facilities	Availability of incubation + links
Personal	F5	Business support staff	Effectiveness of support staff	Availability of support staff
	F7	Links to firms and mentors	Quality of business links and business mentoring and business leadership of incubators	Extent of business links and business mentoring and business leadership of incubators

Table 3.5: Examples of metrics

Figure 3.2 invites periodic use of different lenses or angles from which to view relationalities and causalities in the innovation ecosystem. For example, the ecosystem may appear satisfactory using a global change trend lens, less so using an absorptive capacity lens. For analysts, Framework-1 is a time-consuming reflexive conceptual tool and may (for example in the case of UAE’s innovation ecosystem) result in a monthly ‘progress’ report, a quarterly ‘using this lens’ and next ‘using another lens’ and an annual (or other cycle) stock-taking and trajectory report focusing on reverse salient in the system. Hughes’ (1983) reverse salient theory identifies systems parts holding back overall system performance arguing that improving the reverse salient part has a multiplier effect on the whole system. Goldratt’s (1984) novel graphically illustrates the application of this idea in Operations Management theory. If, for example, the unwillingness of banks to lend to high-growth companies became the reverse salient in UAE’s innovation system, eradicating or reducing this blockage (revealed by analysis) would result in overall improved system performance.

Conclusion

Section 3.1 considered alternatives to the ecosystems approach such as TH and NIS arguing that the ecosystem approach is more holistic and less prone to determinism. Of course, the value of any foresight tool depends upon the quality and depth of data input and the rigour and circumspection of analysis. Twenty-five years ago, Chicago was flooded, the first McDonalds was opening in Beijing, Chicago was flooded, and state asset privatisation in the former USSR was deemed a great success. Who predicted these events and who predicted now, from then? As Linstone (2010) notes, rich multiple perspectives, however imperfect, will offer superior forecasting than (for example) quantitative-only extrapolation of market size or technology trending from which deduced prediction are taken. Since Aristotle we have known the limitations of the *inductive fallacy*: for a self-equilibrating system tomorrow may be like today, but for a competitive socio-economic system the one certainty is that tomorrow will not be like today.

This chapter has brought together lessons learned regarding innovation ecosystems in the form of framework-1; achieved by distilling the 43 factors (Table 3.3) found to influence innovation ecosystems into four thematic groups (Table 3.4): (a) the entrepreneur or innovator agent; (b) legitimacy of the innovation as a new solution; (c) marshalled resources to give life in the form of market, technical and social success to the innovation; and (d) knowledge embedded in the innovative product or service. These factors constitute the consolidatory contribution Nicholson *et al* (2018) call for. Avoiding suggestions of determinism, emphasis is given to the importance of active agency in the innovation ecosystem – principally in the form of the innovator (who may or not also be the entrepreneur bringing the innovation to market). Figure 3.1 displays the 43 factors classified using Linstone's TOPs formula and how they might support processes moving from an old or existing ecosystem into a newly emergent ecosystem that supports a new round of innovations. Framework-1 (figure 3.2) portrays an initial analytical framework that will be used in this research to guide data gathering, data presentation and data analysis. The framework follows Charmaz's research strategy of an initial framework for use in data gathering and analysis, which after triangulation with data allows the creation of framework-2, being the contribution to theory that Nicholson *et al* (2018) call for. How the framework operates and why it is superior to alternatives are discussed in the chapter. This then is the result of a wide-ranging and critical literature review of innovation ecosystems. As the next chapter on methods will show, the framework guides survey questions, interview questions and later the analysis of data, producing in chapter-7 a revised framework, which will be the core of the theoretical contribution from this research. It is to research method that the thesis now turns. Research objectives two and four (section-1.3) have been accomplished in this chapter i.e. a new conceptual framework for analysis of the UAE innovation ecosystems and a rich understanding of the context and culture in which this innovation is occurring.

CHAPTER 4: RESEARCH METHODOLOGY

Introduction

A robust methodology is essential to achieve valid results in social science research, since causal relationships can be more challenging to identify and verify than in physical sciences (Chalmers, 1994). This chapter demonstrates, as Choy (2014) recommends for research rigor, the relevance of the chosen methods to the research problem, research aims, and research questions. It also demonstrates the research reliability and validity as key elements of research evaluation. In doing so, this chapter meets research objective three as set down above in section-1.3 i.e. a robust justification of Charmaz's (2019) constructed grounded theory and justification of major methodological choices.

This chapter outlines the research philosophy and the explains the researcher's distance from the observed behaviour and the participants views. It also demonstrates and justifies the data collection and data analysis methods. In doing so, this chapter bridges between the frame of theorization (See Chapter 3), the research gaps (See chapter 2), and the area of concerns and the research context (See Chapter 1).

The researcher refers to McGregor *et al* (2010) as a methodology handbook for the current research and how he has made his major research decisions. This chapter demonstrates the detailed steps followed in data gathering, its presentation, and analysis in each case justifying choices by reference to methods literature, examples from previous research and suitability to answering the research questions. It also explains a range of philosophical foundations (including, ontological and epistemological stances) to the very practical (sampling techniques, interview guide, questionnaire design and coding techniques). Further, it demonstrates the process of data analysis of 50,000 words of transcribed interviews and data from twenty-seven companies.

Choosing a 'what,' a 'how,' and a 'why' question follows Silverman's (2007) advice for PhD level social research; taking a logical flow from events and their meanings towards explaining why agents make particular choices (companies, Khalifa Fund) and the shape taken by the innovation ecosystem. As discussed in Chapter 1, this research has one main question and three sub-questions. The main research question "*To what* *extent does Linstone's Multiple Perspective Theory help understand the foundations of the innovation ecosystem in the UAE?*" is answered across the whole thesis and starts with focus on Chapter 3. The first sub-question, "*What are the key factors of the knowledge-based innovation ecosystem in the UAE?",* is partially answered in Chapters 2 & 3, but requires further quantitative survey as explained in section 4.5.1. The second sub-question, "*How policymakers and entrepreneurs perceive that the challenges facing the innovation ecosystem in the UAE?",* is answered in Chapters 5 and 6 based on the triangulation of the interview and survey results. The third sub-question, "*How the knowledge-based innovation ecosystem operates at the meta level in the UAE?*", is answered in Chapter 7 based on the full loop of the constructivist grounded theory and theory development.

Following a literature review of innovation ecosystems (See chapter 2), theories of innovation ecosystems (See Chapter 3 and Table-3.3) categorised using Linstone's (2008) TOPs classes and grouped under four themes from the literature in Table-3.4. Again, guided by Multiple Perspective Theory, figure 3.2 suggests a framework for the analysis of innovation ecosystems. This responds to Nicholson *et al's* call for a new framework as a research contribution and to Charma's (2008) research strategy of an initial framework, based on research literature, to be superseded by a second, final framework revised to take account of new data and new analysis. The over-arching research question for this research (RQ) is can this framework help understand and explain how UAE's innovation ecosystem is emerging? From a theoretical viewpoint, this question addresses the gaps in previous literature noted in Table 2.4.

For completeness, Table 4.1 indicates how the quantitative and qualitative questions investigated in this research relate to the 43-factors identified as constituting an innovation ecosystem, the presence (or absence) of which will reveal the quality of UAE's innovation ecosystem.

4.1 Research Philosophy

The realist ontology used in this research and constructivist epistemology is justified in this section, following which the nature of the qualitative mix with quantitative method is outlined. Using an exploratory research strategy appropriate for an under-researched research target, UAE's innovation system is justified as the unit of analysis.

Factor constituting innovation ecosystem	Quantitative questions gathering data (Question numbers)	Qualitative questions gathering data (Question numbers)
F1: Online presence + tools	Question-51, 52, 53, 61	Question-2
F2: Links to UILs/SSIs/Firms	Question-54	Question-11
F3: Fund and partners	Question-5, 54, 55	Question-5
F4: Linkages to MoU agencies	Question-56	Question-1, 15
F5: Business led incubation facilities	Question-52, 53, 54, 60	Question-13
F6: Business support staff	Question-57, 58	Question-2
F7: Links to firms and mentors	Question-59, 60	Question-3
F8: Proof of concept support	Questions-1, 5, 6, 8, 55	Question-4
F9: Market entry and growth	Questions-1, 9, 36 + section-B	Question-5,
F10: Product and its R&D	Questions-2, 3, 5, 7, 10	Question-6
F11: Process technology	Question-11	Question-6
F12: Risk capital access/structures/exit	Question-5, 12, 13	Question-7
F13: Leverage, bank facilities	Question-12, 13	Question-9
F14: Costs and their control	Question-12	Question-4
F15: Supply + logistics	Question-12, 15, 18, 19, 15, 48	Question-11
F16: Leadership	Question-14, 20 + Section-B	Question-
F17: Staff and partners	Question-63, 64	Question-12
F18: Useful knowledge flows	Question-17, 18, 19, 22, 23, 24, 30	Question-5
F19: Education standards/ staff training	Question-21, 24, 25	Question-4
F20: Reputational capital	Question-24, 35	Question-13
F21: Business professionals	Question-28	Question-10
F22: Business mentors	Question-29, 30, 33, 59	Question-12
F23: UILs, company R&D links	Question-22, 23	Question-5
F24: Media representation	Question-31	Question-14
F25: Big company learning	Question-29, 30, 33	Question-3
F26: Business mentors	Question-32	Question-3
F27: Business networks, customer voice	Question-34, 36	Question-2
F28: Entrepreneurs' Legitimacy	Question-26, 35	Question-2
F29: Business professionals	Question-28	Question-3
F30: ICT infrastructure	Question-37	
F31: Regulations: IP, Tax	Question-38, 39	Question-4
F32: Logistics infrastructure	Question-36, 40	Question-5
F33: Rule of law/no corruption	Question-41, 62	Question-4
F34: Policies: grants, business friendly	Question-42, 62, 63	Question-1, 15
F35: Exit market	Question-35	Question-10
F36: Effective labour markets	Question-43, 44	Question-12
F37: Open expert migration	Question-44, 45	Question-12
F38: Clear international standards	Question-46, 47	Question-13
F39: Routes to connectivity	Question-46, 47, 48	Question-13
F40: Complementarities	Question-46, 47	Question-14
F41: Inward FDI learning opportunities	Question-48, 49	Question-14
F42: Involved in R&D networks	Question-49	Question-15
F43: Staff with absorptive capacity	Question-50, 64	Question-11

Table 4.1: Sources of Data for the key factors of Innovation Ecosystem

Social activity can only be explained with reference to active agents, who as Sayer (2000) notes act and interpret actions; interpretations of human activities result in meanings – enactments in time and space – social facts that as Sztompka (1994) argues can only be understood in a social context. For Bhaskar (1978) this ontological perspective, which he terms realism, is an alternative to the *reductio ad absurdum* that 'hard' scepticism introduces. If as Burrell and Morgan (1979) suggest, all meanings are neither equally valid then no realistic sense-making can be distributed, nor bodies of accepted knowledge accumulated. Discovery is a valid methodology in physical sciences, where discovery awaits the researcher, in social science as Kvale (1996) argues, there is no 'out there' awaiting discovery; instead, there are facts that can be interpreted and composed into knowledge. For Sanders *et al* (2003) the realist ontological perspective is necessarily interpretivist: realism acknowledges subjective social reality: realism digs into the motivation, activities and intentions of active agents, contriving meanings and suggesting causal linkages.

A realist ontological perspective Easterby-Smith *et al* (1991) argue, is then necessarily constructivist in epistemology: particular 'facts' are chosen and then interpreted to give meanings: other 'facts and meanings are discarded. These epistemological choices rely on definitions and imputed causalities knitted together by accumulating as diverse a dataset as possible. Following Ilyenkov (2020) we adopt a materialist ontology focusing on human agentic activity, as opposed to the notion that abstract ideas are the cause of social change. In this we differ somewhat from Schatzki (2019) who's pragmatic idealism accords agency to ideals and ideas: our search is for human agents making a significant difference to events and objects. We follow Oshry (2018) and Engeström (2018) in searching for how context and culture influence human decisions, yet do not deterministically control human actions. Abolafia (2010) while conducting a survey, the paramount evidence sought in this research is plausible and coherent stories of human decision-making. In this we follow Nobel Prize winner Schiller's (2019) advice to seek out stories of why and how humans alter the course of events.

In the case of this research mixes both qualitative and quantitative data, seeking to strengthen validity by aligning evidence into a believable narrative. Primacy, however, is given to qualitative research: qualitative questions require qualitative data for answers, in this case checked and supplemented by quantitative data. A narrative, relating to UAE's innovation ecosystem is at best believable and evidence-based, it can never aspire to be the 'truth' since alternative validities will always be possible from alternative sets of evidence and alternative socially constructed narratives. As Godfrey and Hill (1995) argue, the constructivist epistemological stance gains strength from triangulation: the alignment of types of evidence in support of a narrative. In doing so, the researcher must immerse in the research culture and context, adopting an empathetic stance, taking all possible precautions, as Pettigrew (1997) recommends, considering alternative sets of data, alternative interpretations. A constructive epistemology invites researchers to expose their chosen narrative to alternative interpretations, to seek not only verification, but also disputation and alternative viewpoints. In summary, this research adopts a realist ontology and a socially constructivist epistemological stance.

4.1.1 Role of Researcher

A non-Arab conducting this research would have the great disadvantage of limited knowledge of culture and context. Similarly, an Emirati researching UAE's innovation ecosystem without prior knowledge of some of its processes is on a steep learning curve. Of course, familiarisation with literature and previous research helps overcome these knowledge deficits, though in this case research specific to UAE is limited. Foucault (1971) in his Algerian ethnographic studies speaks of *regimes of truth* stressing the importance of pre-understanding as a way of avoiding the misinterpretations Mead and others made (superficial). In similar vein, Wenger (1998) spent twelve months observing the claims section of an insurance company before he felt able to comment on the nuances of learning processes, perhaps informed by Goffman's (1961) view that symbolic interactions can only be understood from a viewpoint of deep cultural and contextual understanding.

In this case, the author has worked in UAE small company start-up and investment (mainly with the Khalifa Fund) for ten years, bringing to the study a rich pre-understanding. Hammersley and Atkinson's (1993) exhortation to *go there and find out* while a useful motivation insufficiently grasps the need for pre-understanding of the research field and the danger of alterity, (the otherization of *cultural others)*. Bryman and Bell (2011) amongst other note how useful pre-understanding can be and Parker's (2000) point that close observation of the research field helps frame the issues, especially invisible roles and relationships.

As Hammersley *et al* (1995) Gold (1997) and Madison (2005) point out, pre-understanding brings its own challenges: bias towards existing agents and processes and institutions. In this study this potential bias was taken seriously with reflexivity on the evidence and triangulation with previous research being the main modes of protection against bias.

In summary, the author was aware of the potential great advantages of deep pre-understanding of the research field, while deliberately taking care to avoid the pitfalls associated with prior connections. As will be noted below the author's connections with the Khalifa Fund were instrumental in gaining access for the survey and later interviews, overcoming an Arab cultural reluctance to speak openly about business matters with strangers.

4.2 Research Approach

This research takes a mixed method approach: gathering as Bryman (2015) advises both qualitative and quantitative data, subjecting each set of data to careful analysis and then weaving the data together to create an honest, believable and consistent narrative explaining the research target; the emergent knowledge-based innovation ecosystem in the UAE. Mixing methods gives confidence to the sense-making narrative by weaving-in verificatory data, triangulating between cross-sectional datasets and reintegrating with previous research results, an approach Silverman (2001) suggests is appropriate when 'what' and 'why' research questions are being asked, as is the case here. In this case, the 'mix' accords primacy to qualitative data, with quantitative data being used to check and enrich the sensemaking from qual

Such a research approach relies on contriving and consistently applying definitions of key factors shaping the narrative outcome. No amount of illusory precision will overcome ill-defined factors as Van Maanen (2000) notes. Indeed, the qualitative element of the research approach taken here gains veracity not from precision and sample size; instead, it relies on the typicality of chosen cases and agents (Miles and Huberman 1994). The mixed methods approach, as Pope and Mays (2000) argue must pay careful attention to extracting decoded meanings from rich datasets: the social world is given meaning the meanings are not inherent in the data. Interconnectedness between the qualitative and quantitative datasets gives what Gummesson (1992) refers to as deep or holistic coherence to the chosen narration of meanings in sequencing events, according to causalities and explaining 'why' outcomes occur.

Seeking depth and richness of explanation here justifies the decision not to conduct an international comparison. This apparently obvious approach as Yin (2003) and Gilbert (2008) argue, should always be considered. As they go on to note if depth is sacrificed to gain comparability, then the trade-off is mistaken. This is the conclusion here: introducing an international comparison would introduce a further evidence base, but at the cost of understanding factors, causalities and boundaries in the UAE innovation ecosystem, taking attention away from the culture and context of the UAE. This is especially important since the innovation ecosystem in the UAE has not previously been deeply researched, is dynamic and emergent and therefore requires new definitions and attributions of 'why' events and outcomes occur. Reading Hammerich and Lewis' (2013) arguments on the dangers of superficial comparisons across cultures, reinforces the view of this research that an approach deeply investigating UAE is superior to one contrasting outcomes with another country: it is the processes of change, the 'why' this research targets. As Yin (2003) notes, a single case approach is justified, provided the case is carefully chosen, deeply analysed and provided that 'why' research questions are being asked.

In summary, the research approach adopted here is a mix of qualitative and quantitative method in a single case study of UAE's innovation ecosystem, justified as a route to investigating 'why' the ecosystem is emerging in particular ways.

4.3 Research Strategy

The research strategy adopted in this research is to use abductive reasoning in an exploratory study. Since Avicenna (980 –1037), as Black (1997) notes, the Arab scientific tradition has rejected the view that deduction and induction are alternatives and instead sought to address the contingent and provisional nature of knowledge by bringing to bear both abstract reasoning and evidential reasoning together. Now termed *abduction*, this is the strategy taken in this research. Abduction is particularly appropriate to an emergent research target such as UAE's emergent innovation ecosystem, since there are no crystallised definitions and causal relationships that can be subject to positivist hypothesis testing, nor is there an absence of data from which conclusions can be induced. Adamson (2016) notes how advanced Avicenna was in proposing a practical science, unlike predecessor Greek science, based on abduction – testing ideas against evidence and formulating new ideas based on evidence.

In adopting abductive reasoning, this research follows Peirce (1955) and Dubois and Gadde (2002): positing a narrative, testing against evidence, re-formulating the narrative into coherent theory. In part this is only possible because of the researcher's pre-understanding, gained from working for ten years with the Khalifa Fund. How innovation occurs, what innovation occurs has been accumulated as informal wisdom over these years and allows the research to begin with some understandings of the UAE innovation ecosystem. Of course, answering the research questions requires a more systematic approach, especially the deeper 'why' question. Here, as Powell (2001) notes, pre-understandings help in the framing of the problem and selection of case material: pre-understanding will not however substitute for systematic gathering of new data and its analysis: the purpose of the current research. As Eisenhardt (1991) argues, applying abductive reasoning (unlike cumulating tacit wisdom) involves clashing ideas, disputing meanings and rethinking presumptions. The intention of this research is to combine abductive reasoning with the use of a newly constructed framework to be tested against evidence and previous research and then, following Charmaz (2008) to prepare a final framework, as a theoretical contribution to understanding innovation ecosystems in a culture and context such as UAE.

Following Bateson's (1972) idea of framing to establish meanings and Goffman's (1974) notion of a *schema of interpretation*, we look for incidents, resulting from events (Entman 1992) within which we can give frame-referencing, such as an innovation or company startup. Chu (2017) recommends this approach. As Levin (1998) this is not possible from quantitative research and requires in-depth reflection on qualitative data, what Raelin (2008) terms *emancipatory discourse* i.e. making a story, within a frame where the causalities are clearly established: Bradbury Jones *et al* (2017) a meaningful *synthesis of evidence* within a well-chosen frame. Oughton and Bracken (2009) note that this approach, which aligns closely with CGT, requires the researchers to frame and reframe the research as stories emerge and/or counter-evidence emerges: effective framing is also reframing (Nicholson *et al's* replicatory research conclusions). This avoids the need Klein *et al* (2010) suggest for setting data-frame criterion prior to analysis. The CGT approach, as we note above (Charmaz 2008) establishes an initial frame based on the literature and previous research and then a final framework as a contribution to theory: this is the path we follow, as recommended by Parfrey and Ravani (2009).

This research is exploratory as Bryman and Bell (2007) and Sekaran and Bougie (2013) interpret the term i.e. agents and causal relationships in UAE's emergent innovation ecosystem are as yet emergent; the situation is fluid and dynamic. Exploratory research acknowledges this indeterminacy. An exploratory study is appropriate *when some facts are known but more information is needed for developing a viable theoretical framework* as Sekaran and Bougie (2013:96) argue. Had UAE's innovation been less clear than an introductory ethnographic study might have been used, however, innovation has patterns of practice in the UAE suggesting that the research can go deeper than a 'frontier' ethnographic study. However, the patterns of innovation in UAE are not sufficiently crystallised to support the clear definitions and causal relationships necessary for positivist hypothesis testing. Hence, following Yin (2009) this research will use a case study approach to explore 'what,' 'how' and 'why' the innovation is emerging in UAE.

A case study is a story with a point; the point being created by using a theoretical structure derived from relevant previous research. The case approach as Yin (2009) argues is ideally suited to narrative construction, since its internal coherence relies on events and agents' actions explaining how and why outcomes occur. A case study strategy is not a research method: it is a method guiding data gathering and its presentation not analysis. Analysis in this case will be guided by Charmaz's (2008; 2019: 2020) constructed grounded theory, whereby an initial framework is constructed using factors derived from previous research, this is then tested against the 'facts' in a case study (in this case of the Khalifa Fund), and then a final framework is suggested fitting both the 'facts' as accumulated from data and in the case and also triangulation with previous research. Analysis therefore in this exploratory study is thematic: themes taken from previous literature and embedded in framework 1.

To summarise, the strategy adopted in this research closely follows recommendations from research literature (Bryman and Bell 2007; Charmaz 2017; and Yin 2009): it is exploratory since events and outcomes are emergent, abductively reasoned to integrate ideas with evidence, uses a case study approach to present a narrative, with analysis structured by the journey from framework-1 to framework 2. There is a clear symmetry between the ontological and epistemological basis of this research (Ilyenkov), with the CGT research strategy (Charmaz), the framing of data gathering and analysis (Entman) and the triangulation to create new theory by contrasting results with previous research.

4.3.1 Unit of Analysis

UAE's innovation ecosystem is the unit of analysis for this research. This is chosen to provide a holistic view of innovation in UAE. Alternative units of analysis such as particular technologies or agencies (Government, Khalifa Fund, companies) would provide a more partial footprint and therefore less holistic perspective.

Choice of innovation ecosystem as unit of analysis allows the research to move between different scales such as international markets, national initiatives, sectoral systems, companies, individual entrepreneurs, and funders.

The innovation ecosystem is the unit of analysis and not the level at which data is gathered (Davidson and Wiklund, 2001). Data will be used here from each of the levels of scaling mentioned above, in each case interpreted through the lens of the unit of analysis – the innovation ecosystem.

4.4 Research Design

In practical terms this research aims to achieve three outcomes: to understand, theorise and practically guide UAE's innovation ecosystem. An ever-present danger in social research (the inductive fallacy) is suggesting that tomorrow will be like today – in short determinism. All the major innovation theorists view determinism as an enemy (Rosenberg 1982), particularly where technologies are involved. In this research avoiding determinism is achieved by including active agency in the ecosystem narrative. Decisions and actions by entrepreneurs, policymakers, Fund Managers introduce non-linearity and unintended consequences where simple extrapolation from the 'logics' of technology can alternatively suggest predictability and linearity. Archer (2003) insists that though institutions and culture influence agents, the agents in turn by logic of practice (Gidden's 1984 term) in turn reshape and influence institutions. The research design here is chosen to avoid determinism and ground theorisation in evidence and the decisions and actions of participant agents.

These are the premises on which Glaser and Strauss (1967) based their grounded theory (GT) approach avoiding de-centred agency, the 'logics' of meta social theory and attribution of causality to abstract social forces such as class, market or globalisation. In doing so Glaser and Strauss established an alternative to discourse confined to positivist methods and to 'big' theory explanations of particular social movements, such as the particular innovation ecosystem in UAE. One principle of GT is that each event or decision has alternatives, what Ricoeur (1995) terms *paths not taken*. Grounded analysis then constructs a narrative, part of which is explaining why in particular circumstances decisions and actions were taken and not others.

Glaser and Strauss' (1967) idea was to gather data, abduct a theorisation and then test this against the findings of previous literature. The aim of grounded theory is: *'to generate or discover a theory'* (Glaser and Strauss, 1967) the discovery of theory from data systematically obtained from social research' (Glaser and Strauss 1967:2). It is ideal for exploring integral social relationships and the behaviour of groups where there has been little exploration of the contextual factors that affect individual's lives.

As Charmaz (2017) points out, it is impossible for researchers, educated in theory and knowledgeable about frameworks to approach research without implicitly using this previous knowledge i.e. having a *point of departure*. She suggests instead a constructed ground theory (CGT) based on Glaser and Strauss's work – this is the research design adopted in this research. CGT prepares an initial framework-1 from existing theory; this may range from concepts and definitions in under-researched areas to a fuller (boundaries, causalities) framework in areas that have been subject to deep research. Framework-1 guides the data gathered and its thematic presentation and analysis (often coding), the results of which are incorporated into framework-2, which becomes the theorisation from the research by contrasting the actual interpretation with that expected from previous research. Dey (1999) by adopting the constructivist grounded theory approach, the researcher moves grounded theory methods further into the realm of interpretive social science consistent with a Goffman (1974) emphasis on meaning, without assuming the existence of a unidimensional external reality (Charmaz 2000: 521). Dey point out that prior knowledge always makes a difference to interpretation and epistemologically to what 'facts' are seen as worthy of gathering: an open mind, does not mean an empty head.

Bryman and Bell (2011) suggest that for *exploratory* research, such as this, CGT is an appropriate research design, avoiding determinism by allowing themes to emerge (from literature and coding). As exploratory research we use quantitative data to support (or challenge) the conclusions from our main data sources, which is qualitative. Since CGT creates framework-2 by triangulating with previous research, it produces what Llewelyn (2002) calls intermediate level theory i.e. theory the generalisation of which may be limited and calls for recontextualization prior to application elsewhere. In this case, two datasets (quantitative survey of firms and qualitative interviews with key agents) support the creation of a thematically structured case study, key points from which can then be compared and contrasted with previous literature on ecosystems, innovation in the three target sectors and change initiatives in an Arab culture and context.

4.4.1 Research Context: Khalifa Fund

The Khalifa Fund (KF) is the UAE's principal economic development agency charged with promoting business growth to deliver the *2030 Vision* of an innovation ecosystem that creates a sustainable high-income society. KF's levers include encouraging entrepreneurial spirit, providing risk capital and credit guarantees, and lobbying for a supportive business environment for both youth and early retired entrepreneurs.

4.4.1.1 KF capabilities

KF offers professional entrepreneurial services to guide new entrepreneurs. Who are planning to be a part of the SMEs Ecosystem Its SME Toolkit http://uae.smetoolkit.org/uae/en is customized to the UAE regulatory context and includes online step-by-step business planning. KF sponsors attendance at relevant events and is able to help negotiate starter Government contracts. The KF's website celebrates an array of success stories.

4.4.1.2 KF interactivities

Reflecting the digital native nature of young Emiratis, the KF Gateway for budding entrepreneurs, businesses, and Government agencies http://www.kfgateway.com/en is a well-designed, easily navigable, impressive online space that encourages interaction between registered members. Key partners accessible via the site include the Abu Dhabi Food Control Authority (standards and monitoring) and thirty MOU organisations each offering concessionary services to KF companies. These range across Abu Dhabi Chamber; to Police; Tourism Authority; Al-Hiial Bank; Al-Alin Cooperative Society; the Critical National Infrastructure Authority; Departments of Economic Development and Finance; Entrance Real Estate' Etihad Airways; the Fujairah's Municipality; Chamber of Commerce and Industry; Tourism Authority; the ICT Fund (technology investors); LuLu online trading portal; Ministry of Labour; National Network for SMEs; Royal Business Centre; Union Corporation; Wall Street and Zones Corporation.

Working closely with all incubators in UAE, the KF Chairman, Hussein Jassim Al-Nowais, focuses the Fund's activities on innovative companies in emergent sectors, saying in 2015,

> *The ecosystem for innovation in UAE has grown rapidly as Abu Dhabi 2030 vision gives lots of importance to the education sector and put it as a top priority to ensure the best outcome from the education process. Also, it is part of the leadership beliefs in the importance of investment in human capital and improve it by the highest international standards in the education sector, which has to adopt 21 per cent of the UAE federal budget.* (Emirates News, 22112015):

Leading innovation-entrepreneurial capacity, the KF supports a wide array of training services and over 5,000 business counselling and development projects this year. This research will comment upon the role of the KF leading the innovation ecosystem development in UAE.

4.5 Data Collection Methods

A major issue in all mixed methods research is sequencing in practical terms, whether to conduct the quantitative or qualitative research first. This issue involved considerable thought in planning the research since in my case there were no outside limitations: either sequencing could have been chosen and both datasets were equally important to the research. This is a difficult issue since there are clear advantages to both approaches.

Miles and Huberman (1994) and Bryman (2008) suggest the advantages of conducting the qualitative research first are using it to map out the issues and thus inform questions in the later quantitative research ensuring that the major topics are covered. Alternatively, these research methods books suggest the advantages of quantitative research preceding qualitative are that the qualitative research can then deeply explore unexpected outcomes revealed by the quantitative data. Yin (2009) notes that where the quantitative survey covers similar respondents as the later qualitative, then the advantage of quantitative research first is to give an overview of the research terrain, followed by in-depth cases that include investigation of interesting topics revealed by the quantitative research. Gummesson (2009) argues that a key part of this decision is which way around allows the best integration of the data, noting that in the case of deep case studies answering 'why' questions qualitative research is best done second. In this case since the research is exploratory, ruling out hypothesis testing since definitions and relationships are emergent, Yin's arguments appear valid.

This conclusion was supported by reading research methods oriented towards hypothesis testing. For example, Wisdom *et al* (2013) and Munk *et al* (2017) are definitive that qualitative research preceding quantitative allows opportunities to frame hypotheses that can be testing in the later quantitative research. Paton (2015) recommends this approach, where the key findings from the research are likely to be quantitative: this is not the case in this research.

Charmaz (2006) favours mixed methods as providing opportunities to triangulate between datasets. She argues that constructed grounded theory is an invitation to deeply explore 'why' questions and that these are best framed following quantitative research, with the qualitative element always being sequenced to follow. Her view is that grounding theory in logic-of-practice necessarily requires an out-to-in approach, with research moving towards ever deeper investigation into 'why' issues. Her emphasis (2016) includes taking the time to reflect upon how expectations (before data gathering) match data actually gathered and attributed meanings. Indeed, Charmaz's (2019) interviews of researchers using CGT finds that for many researchers this self-reflection introduces an additional layer of criticality.

Having pondered a great deal on this sequencing issue and noting the advantages of both approaches, Yin and Charmaz's arguments persuaded this researcher to undertake the qualitative research first. As exploratory research it makes sense to gather the primary data first and the secondary data second. A look ahead to Chapter 5 confirms the correctness of this approach for this exploratory research. The chapter refers to qualitative interviews based on supplementary questions that could not have been asked had the qualitative work not been done first. Had the research not be exploratory and able to support hypothesis testing, reversing the sequencing may have been beneficial. In this case however, ease of integrating the datasets by conducting the qualitative research first has been of proven value in the flow of the research.

4.5.1 Survey Method

The flow of this research is from in-to-out: from specific companies to the wider institutional arrangements constituting UAE innovation ecosystem. Therefore, the sequencing of interviews with policymakers first followed by survey logically followed. Since the UAE Government's *Vision 2030* specifically identifies software, non-carbon technologies and life-science products as target technologies, gathering data from start-up and early-stage companies in these three sectors aligns with the research aim of mapping and analysing the emergent innovation ecosystem in UAE. A company dataset grounds the research in patterns of practice in UAE's innovative sectors and having identified 43 factors constituting an innovation ecosystem, the purpose of the survey was to accumulate data on how innovative companies are experiencing these factors in practice.

4.5.1.1 Why a survey?

Surveys, Bryman, and Bell (2011) argue, allows inferences relating to a population to be made from a sample. Often, as in this case, the sample size though smaller than the population is larger than could be interviewed. Contriving a sample, Aday and Cornelius (2006) and Cohen et al (2007) note, allows the researcher to compose a representative sample (in this case by sector and stage of company) from which to make statistical inferences. Surveys are widely used research instrument for quantitative research and as Choudrie and Dwivedi (2005) their use has become easier given the high convenience and low cost resulting from communications technology.

For this research a self-completed questionnaire, hosted by Survey Monkey and distributed via email was chosen, with respondents having previously agreed by either telephone or email to participate. All respondents confirmed consent to participate by email. As Stangor (2007) notes, the survey is an efficient instrument for quickly gathering large amounts of relevant data. Properly designed, as Cohen et al (2007) suggest, the survey questionnaire can cover a wide range of issues, which if robustly analysed (using statistical techniques) can reveal in total much more than the aggregate of data gathered.

Gathering quantitative data enables triangulation with qualitative data and previously published quantitative results. As Yin (2008) argues, too much institutional research deduces general conclusions from single or small number case studies. The survey introduces a further triangulation point enhancing the validity of this research.

4.5.1.2 Survey Sampling

Sampling creates a representative subset of the population achieved by probability sampling or guided theoretically or by typicality (Bryman and Bell 2011). Probability sampling presumes that rests each population member has the same selection chance. Given the importance of factors such as age and technology, this research decided against probability sampling in favour of a thematic sample i.e. chosen as fitting qualifier conditions.

In the literature sample size recommendations are often guided by decisions around Exploratory Factor Analysis (EFA) or Confirmatory Factor Analysis (CFA); the latter case is hypothesis-testing for which a larger minimum sample size is recommended. For example, Comrey and Lee (1992) propose a sample size of 300 for CFA. In the case of EFA a smaller, though more deeply typical sample size is required i.e. subject to more qualifier conditions. In some cases, Tinsley and Tinsley (1987) propose that a sample size as low as ten may be appropriate. A key qualifier condition, in this exploratory research is gathering data from each of the three target technology sectors. It was decided to take a sample of ten companies for each sector, making a sample size of 30. Given the wide range of questions proposed, this sample size provides a statistically significant database. Double the sample size to 60 would not have added validity, reducing the sample size may have detracted. Given the cultural difficulties in getting firms to participate, the eventual sample size was reduced to twenty-seven: eleven software companies, life-science companies and nine non-carbon companies.

A thematic sampling technique was employed in this research resulting in qualifier conditions making the sample typical of innovative companies in the three chosen sectors. Seeking to identify non-trading or failed companies was considered, however, the obvious problems are that they no longer have a location or contact address and it is unlikely (certainly in an Arab culture) that the respondents would cooperate in speaking about failure.

The thematically construct sample of 27 companies met the following qualifier conditions.

- Each of the companies operate in the three target sectors, as defined by (Industry classification) i.e. their products use technologies and knowledge from the stated sector.
- Companies are start-ups or early stage meaning they are trading and have not been trading for more than five years (GEM criteria for early stage)
- They have a minimum turnover of US$ 1 million and though no maximum was imposed, a turnover likely to be under US$ 10 million, since that is a point at which new capital injection is required and ownership may change (cite)
- Companies are Emirati owned and managed: a difficult criterion to meet since publicly available data (i.e. prior to questionnaire completion) it may not be clear if external and international capital is involved.

These stringent qualifier conditions for the sample of 27 companies meets Saunders et al’s (2009:588) prescription for EFA in that their typicality is deeply defined: the sample’s representativeness derives from typicality and not size. The sample has both heterogeneity and homogeneity: the former segmenting by sector and the latter gathering respondents by strict thematic criteria. The company’s detail is stated in Chapter 6.

4.5.1.3 Survey Design

This is exploratory research since UAE's innovation ecosystem is (a) under-researched and (b) emergent and rapidly evolving. Therefore, as Gilbert (2008) hypothesis testing is inappropriate since definitions and relationships have yet to crystallise. The questionnaire design therefore aims at Exploratory Factor Analysis rather than Confirmatory Factor Analysis and is designed accordingly.

Following discussion with Supervisor, the survey was conducted in English, which is the business language most often used in small, internationalising companies in UAE. One advantage of this was precision in language and another ease of results tabulation and analysis. Events proved this decision unproblematic: no single respondent reported any difficulty in competing the English language questionnaire.

Had a similar study been conducted in a similar culture and context it may have been desirable to conduct a confirmatory study. In the absence of this previous research, as Bourque and Clark (1992) and Saunders et al (2009) note, this leaves no option other than designed a new questionnaire. Approaching this task was guided by Wilkinson and Birmingham's (2009) advice to be short, clear, and unambiguous, especially since as Gillham (2000) notes, once distributed the questionnaire cannot be recalled.

Essentially, the questionnaire (see Appendix for complete questionnaire) is in two parts: firstly, socio-demographic information on the innovator/entrepreneur and background on the company and secondly, questions eliciting data relating to the 43 factors of an innovation ecosystem identified in the literature review (Table-3.3).

The survey was designed for delivery via an email link to Survey Monkey chosen for the following reasons.

- Secure and anonymous giving confidence to respondents
- Simple and easy to use
- Range of question styles
- Offers first pass integrated data

Design choices were guided by time to complete (target 20 minutes, see Buttle 1996) and avoiding intrusive questions resulting in incomplete returns. Most of the survey questions are multiple choice, inviting the respondent to highlight the button indicating their data point, care was taken to avoid overlap categories as (Alosaimi 2013) advises. Most questions are therefore ‘closed’ rather than ‘open’ exceptions being question-X asking about networks generating ideas and the final questions relating to impressions about UAE’s innovation ecosystem. The closed nature of the questions and use of Survey Monkey allowed the use of simple buttons; remembering that business surveys are uncommon in UAE and simplicity is paramount. Survey design avoided more complicated answers, for example asking the respondent to calculate percentages, use a slide or Likert scale. Since the survey was conducted in English language there were no incompatibilities with Survey Monkey.

4.5.1.4 Survey pilot

Following Bell’s (2005) advice two-stage pilot resulted in ironing out eight ambiguities, confirming Van Teijlingen et al’s (2001) suggestion that taking the pilot seriously brings worthwhile results. Firstly, three people with expertise were asked to comment on the lucidity of the questionnaire: two were native English-speaking PhD students at Salford University and the third and Teacher of English language working in UAE, known to the author. Secondly, companies Y and Z were asked to pilot the questionnaire, their results are included in the survey data since neither found any of the questions confusing or unanswerable.

4.5.2 Interview Method

Table 1.2 noted that following the survey, this research will use the results of interviews with twenty-one key agents active in UAE’s innovation ecosystem: eight policy makers (trade, finance, education); eight incubation Managers and Managers of three commercialisation units at three universities. Following initial analysis, interviews (three) will then be held with the two key leaders of the Khalifa Fund (in part responding to the perceptions of other agents on the Fund’s role in UAE’s ecosystem).

Understanding of UAE’s innovation ecosystem requires richer data than survey responses: how do key agents construct/perceive the ecosystem, what are the key roles and relationships that make it work, how do agents judge what and how to change as events and changes in other factors unfold? Bryman and Bell (2011) suggest that interviewing is the fast track to richer qualitative data, hence the use of interviews here, which are guided by the approach set out in Gilbert (2008).

4.5.2.1. Why F2F interviews?

Twenty-one elite interviews are a challenging target and would be much easier achieved with a short self-completed questionnaire. However, the aim of the interviews is to generate rich data on the roles, relationships and reactivities in UAE's innovation ecosystem: this can only be achieved by face-to-face (F2F) semi-structured interviews allowing probing and the pointing of interviewees towards narratives exampling ecosystem activity. Additionally, in the Arab culture favours (such as an interview) must be conducted personally, this is especially the case for an elite interview cohort, where suitable respect must be shown to the positions occupied by the interviewee. For all these reasons F2F interviewing was selected as the appropriate research instrument. Consideration was given to alternative paths. Gilbert (2008) points to the advantages of Group interviews or Focus Groups as revealing interactions and even disputes between respondents. However, an elite group are unlikely to participate, perhaps fearing the dignity of their positions would be jeopardised. Also, saturation requires digging deeply into interviewees reasoning around policies and actions: this is difficult to achieve in a one-to-one interview and even less likely in a group.

Cognitive conversations were also considered as an interview technique, having the advantage of allowing interviews to choose terminologies and causal linkages. In this case, however, the interviews aim to reveal in a more focused why how the innovation ecosystem works, rather than accumulate generic data about UAE innovation and prospects. The semi-structured format allows the researcher to maintain focus and direct question sequencing and probing and prompting. Establish rapport with interviewees enabling requests for elucidation and supplementary questions.

4.5.2.2. Interview Sampling

How much data and how many interviews are necessary before saturation is reached in accumulating data to understand roles, relationships, and reactions in UAE's innovation ecosystem? As in all developing countries the state plays an important role in establishing hard and soft governances: structures and institutions influencing how knowledge is created and exploited and how businesses develop. Three areas of state activity in particular are important (development state literature): education – to create a knowledge workforce for a knowledge economy; finance – enabling the marshalling of financial resources to implement innovations and trade – enabling the importation of knowledge, capital and people and the rapid internationalisation of indigenous innovative companies. This research will therefore identify senior level Government Officials in education, finance and trade for interviews as shown in Table-4.2 below. While connections and support from the Khalifa Fund will help with access, interviewing senior Government Officials in UAE is no easy matter, this consideration, and the likelihood that one interview will provide sufficient data - Charmaz (2006) gives similar examples - led to the decision that one interview for each of the ten areas of expertise is sufficient.

Unlike non-knowledge micro-businesses that rely on skills and localised markets, from which they are unlikely to grow (barbers, vehicle repair, small retail), knowledge-based innovative business has products embedding complex formal knowledge and have some potential to internationalise: their launch and growth path is therefore quite different. Additionally, knowledge-based businesses often originate from technical expertise (often university-based) adding business acumen later, (research suggests that most academics cannot cross governances). The research therefore decided to interview incubation managers and the managers of university commercialisation units, representing key areas for innovation business start-up and growth.

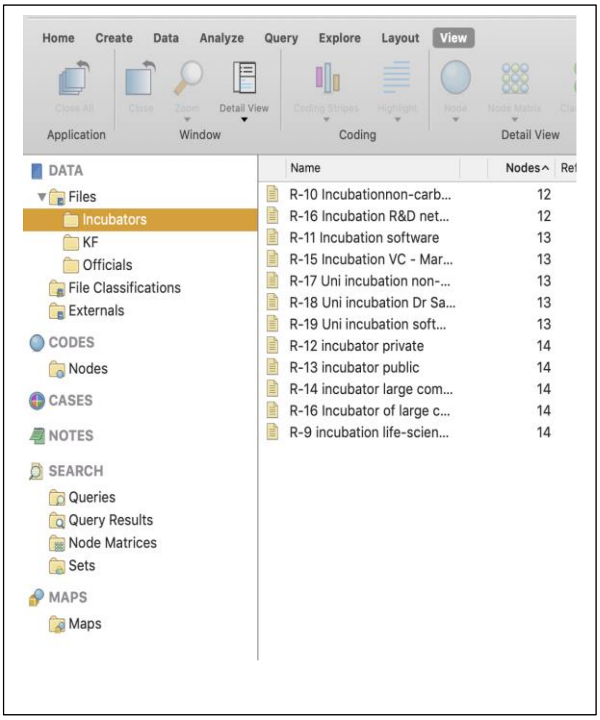
The Khalifa Fund is the principle economic development agency in UAE and the subject of a case study in this research since it occupies a pivotal role in UAE’s innovation ecosystem. After an initial analysis of the quantitative and qualitative data, interviews will then be conducted with two leaders of the Khalifa Fund giving the opportunity for them to respond to how other key agents view the Fund. Two interviews will be conducted: CEO and Head of Strategy.

Somewhat different questions were using for each group, reflecting their different experiences and research areas of enquiry. Care was taken to follow Gilbert’s (2008) advice was followed in designing the question avoiding double-barrelled or personally sensitive questions, balancing question openness with the privacy culture. Interview time was limited (estimated at 90 minutes), design therefore adopted Bryman and Bell's (2008) advice to follow a structure logical to the respondent, the questionnaire is in three sections (see Appendix-X for an example, containing sixty-four questions.

Respondent Code	Interviewee	
	Government Officials	
R-1	Education: School curriculum including vocational content, entrepreneurship education	
R-2	Education: University R&D funding	
R-3	Finance: corporate tax and incentives for small business start-ups	
R-4	Finance: policies towards bank lending to SMEs	
R-5	Finance: grants and state aid to SME business development	
R-6	Trade: inbound capital, people, and knowledge	
R-7	Trade: international of small businesses support	
R-8	Trade: relations between large IFDIs and indigenous SMEs	
R-9	**Incubation managers**	Specialist life-science
R-10		Specialist non-carbon
R-11		Specialist software
R-12		Private sector Incubator Manager
R-13		Public sector Incubator Manager
R-14		Incubator attached to large company
R-15		Incubator attached to venture fund
R-16		Incubator attached to international R&D network
R-17	**University commercialisation Managers**	Manager with expertise in life-sciences
R-18		Manager with expertise in software
R-19		Manager with expertise in non-carbon
R-20	**Khalifa Fund Leaders**	CEO of KF
R-21		Strategy Manager of KF

Table 4.2: Summary of interviewees providing qualitative dataset.

Many questions began, "*Can you tell me a story illustrating and reflecting the narrative method of data gathering?*".



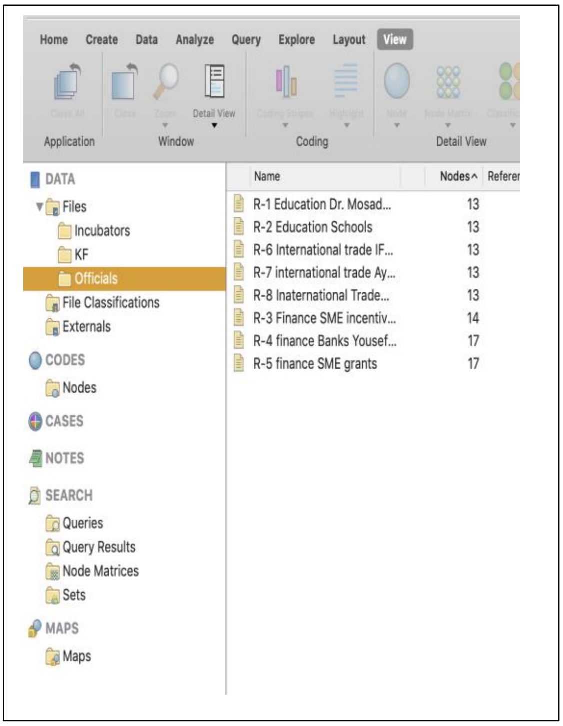


Figure 4.1: Screenshots of selected interview data imported into NVivo

The first three interviews were taken as pilots, since none resulted in significant changes to the questions – actually, only two words were altered to give greater precision following the first three interviews.

All interviewees were informed of the purpose of the research prior to interview and a signed letter of consent obtained (see Appendix C for an example). Permission was sought to record the interviews, which were then translated and transcribed (all were conducted in Arabic so as not to limit the interviewees' ability to express themselves or to introduce bias from some interviews in different languages). After which, raw transcriptions were dropped into NVivo for analysis as shown above in figure 4.1.

4.5.3. Theory building

A major goal of this research is to make a theoretical contribution in the field of innovation theory, innovation ecosystems and the role of learning and entrepreneurship in successful innovation in the UAE culture and context. This contribution will not be what Llewelyn (2003) terms *grand theory* i.e. universally applicable causal relationships between factors. Instead, the contribution will revolve around conceptual definitions for the UAE ecosystem and a new framework for the analysis of innovation ecosystems: this is middle range theory situated in the boundaries, factors and relationships between factors constituting an innovation ecosystem and addressing gaps in the literature featuring in Table 2.4 and responds to Nicholson *et al's* (2018) notion of framework as theoretical contribution. We follow Nicholson *et al's* advice in systematically setting out the research conclusions. The conclusions chapter details a publications and impact plan from this research.

4.6 Data Analysis and Triangulation

4.6.1 Data Transcription and Translation?

Crossing cultures and linguistic bridges is a dominant feature of this research, which may not be so apparent to the reader of an English language thesis. Methods theory books, such as Gilbert (2008) and Sekaran and Bougie (2013) do not mention working in different languages, and Bryman and Bell (2011) devote one paragraph in which they suggest back translation. Yet, conducting a survey and interviews in Arabic about events and decisions occurring in an Arab culture and context poses major issues for the researcher. Some of these are 'technical' in the sense of choosing translated words and phrases; this relies on the language competency of the researcher, focus on natural meaning Manguel (2006; 2008) rather than precise words used and in some cases is helped by referencing terminology used in previous (English language) research. A deep problem identified by Holliday et al (2004) note in their study of *Inter-cultural Communication* is explaining culturally embedded frameworks, metaphors, and meanings (Lakoff and Johnson 1980). This research follows Polkinghorne's (2007) advice and seeks to highlight where cultural influences affect decisions and actions, for example in the exercise of personalised (as opposed to distributed) leadership or paying more attention to Government preferences than might be expected in western societies. Although a short section in this methods chapter, for an international researcher these issues are posed every day during this research.

4.6.2. Data Coding

Using NVivo facilities, considerable time was spent familiarising with the data. For example, generating Word trees: figures 4.2 and 4.3.

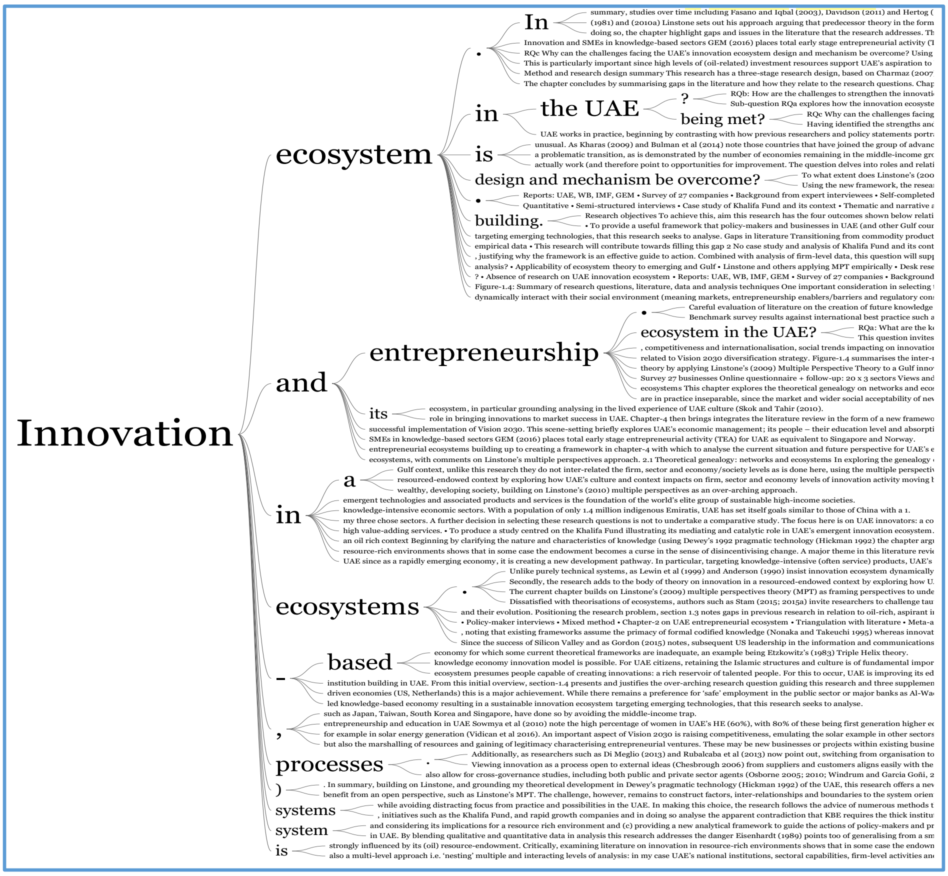


Figure 4.2: Word Tree for incubation (NVivo)

Figure 4.3: Example word tree

Word clouds were generated (example in figure 4.4) revealing from raw data (hence the presence of my Arabic questions) concept frequency.

Figure 4.4: Word cloud of raw data from interviews

Process of data-reduction followed the cycle recommend for NVivo users (figure 4.5) recognising that NVivo is an assistive tool, not itself a method for which I took instruction from Gilbert (2008) and Bryman and Bell (2011).

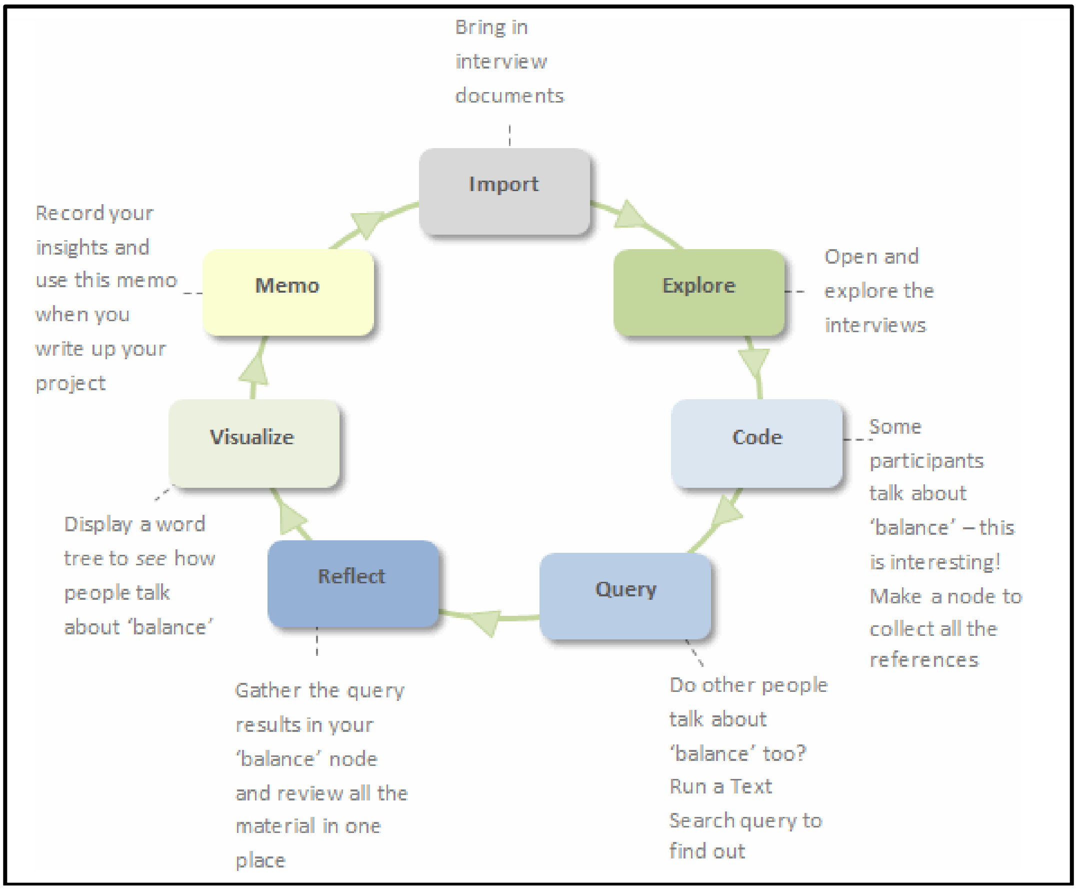


Figure 4.5: NVivo's recommended processes for data reduction and coding

Finding online memoing cumbersome, memoing was done manually, using coloured sticky papers. At this time codes, patterns and themes began to emerge, guided in searching initially by the conceptual framework (figure 3.1). Figure 4.6 captures the process of coding diagrammatically.

On the left of figure 4.6 are shown the first manageable list of thirty-one initial codes, moving rightwards to a second and third set of codes. At this point, codes were categorised into coded-themes, primary codes, and patterns. After a great deal of reflection, iteration and trial-and-error, a combined set of themes, secondary codes and patterns crystallised: show in the middle of the figure. Further combination of codes, tweaked later, even during the writing of chapter 5, resulted in a final set of themes, secondary codes and patterns from practice shown on the right-hand column of figure

4.6.3 Representing a saturation point in coding.

It is this set of coding that was used in analysis. The final set of coding hierarchy is sufficiently close to the concepts in the figure 3.2 to give comfort that the research results are not outside of the field of literature.

The five primary coded themes: (1) innovators leading/strategizing; (2 building business organisation and links; (3) resource marshalling, including finance; (4) knowledge flows and exploitation links; and (5) UAE institutions, provide a coding hierarchy the forms the basis for presenting and analysing the interview data in chapter-5. This coding hierarchy aligns with (though is different from) the categories from the conceptual framework in figure 3.2. This suggests the coding categories bear a similarity to those in previous research, giving comfort that the research output is not an outlier.

The patterns from practice shown in the bottom-right corner of figure-4.6 represent interactivity in UAE's innovation ecosystem and therefore importantly draw attention to how active agents in the ecosystem respond to events and the actions/interpretations of other agents. These patterns are (a) developing technology capabilities; (b) assembling/linking people; (c) building operations; (d) start-up and growth phases of companies; (e) knowledge links for future products i.e. innovation pipeline; and (f) capability to do business with i.e. legitimacy. It is in these patterns that the data generated here most closely align with Linstone's (2011) Multiple Perspective approach, since they move between levels of activity.

This section indicates how overall validity, general and theorisation are envisaged in this research.

4.6.4 Validity of qualitative data

Section-4.6.3.4 considers the validity of this research project; here the validity of the qualitative element of the research is discussed, primarily the internal validity. As Mason (1996) argues validity requires that data gathered is justified as relating to the research questions asked, which this research has done earlier in this chapter and was summarised in Table 1.2.

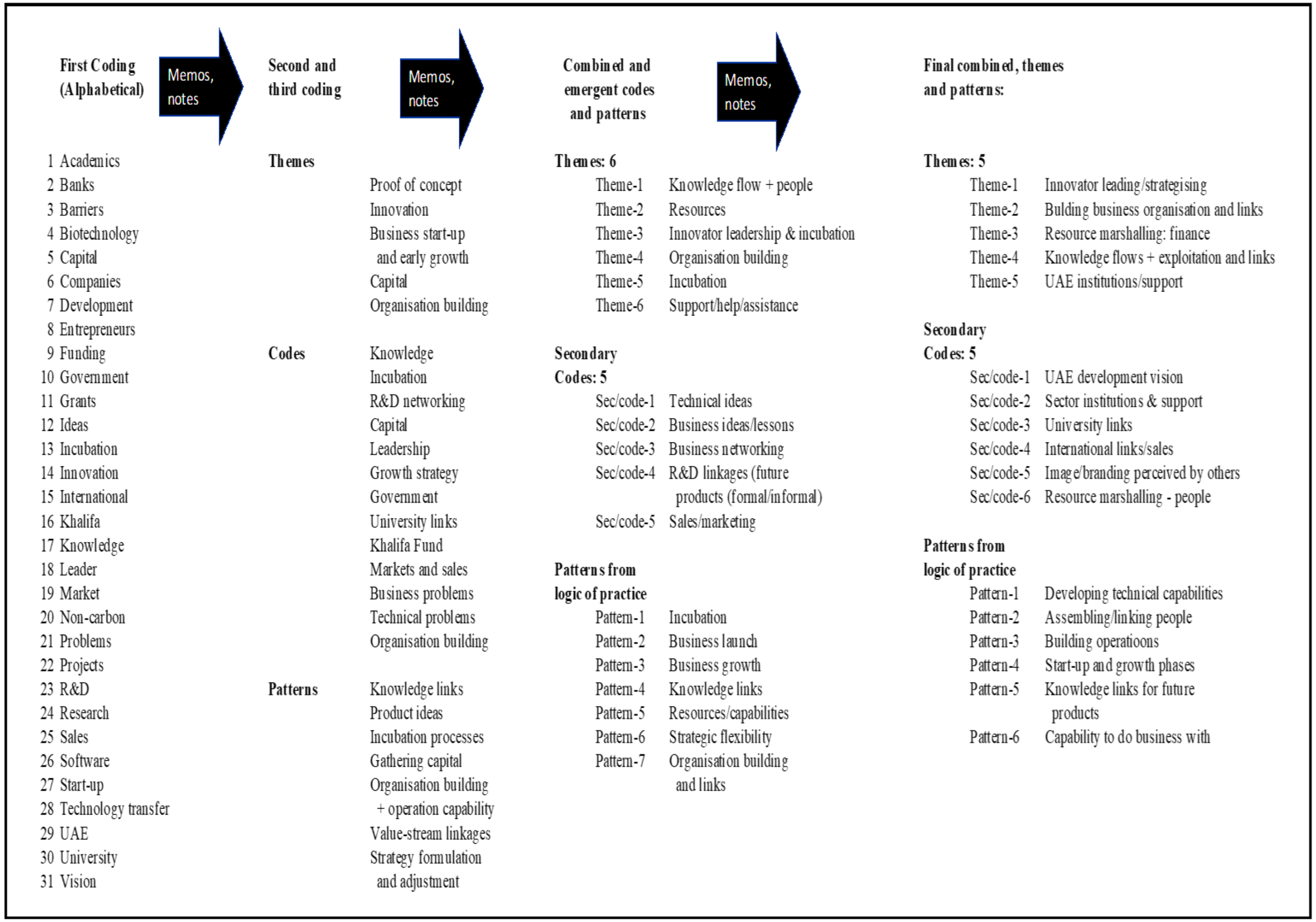


Figure 4.6: Process of coding and theming data using NVivo

4.6.4.1 *Validity, generalisation, and theorisation*

Another standard of validity for qualitative research proposed by Guba and Lincoln (1994) is trustworthiness and credibility in the eyes of participants in the research (in this case the 21 interviewees), signalled by their preparedness to participate and acceptance of transcripts as a fair record of their contribution. Examiners and subsequent journal paper reviewers also judge trustworthiness and credibility – an unknown outcome yet for this research. Another test of qualitative research validity the results of which cannot yet be known proposed by Gilbert (2008) is that the research is honest and repeatable; honesty is a claim the researcher can make, repeatability is for others to judge.

Bryman and Bell (2011) emphasise triangulation as validating qualitative research, in this case a major part of the analysis in Chapter-7, which triangulates with previous empirical and theoretical research relevant to the field of innovation ecosystems. Where qualitative research adopts similar methods to previously published research, in this case for example Linstone's (2011) work on Japan and Arthur's (2015) work on economic ecosystems, this gives comfort and suggests validity. Finally, cross-sectional comparison, in this case between the -survey and qualitative interviews (conducted in Chapter-7) suggests no major dissonance in the qualitative data relative to the quantitative data i.e. even though different opinions may be expressed, they both are clearly evidencing the same social reality. In summary, it seems reasonable to claim that having moved from justifying methodologies and each stage of qualitative method that the qualitative element of this research can claim validity in the sense of usefulness – the subject of the wider validity of this research, towards which discussion now turns.

4.6.4.2 *Validity and manipulation of Quantitative Data*

One advantage of Survey Monkey is that progression through the questionnaire is only allowed upon answering each question. Screening, as Cohen (1999) recommends was thus simple – all questionnaires were fully complete.

Screening in this case (i.e. simplifying classes and factors to make the data more revealing) was quite straightforward since all questionnaires were completed in full and the classes of factors (student/teacher; male/female; experienced/inexperienced) had been designed-in to the questionnaire Cohen (1999) provided clear guidelines for screening or cleaning questionnaires.

It is possible to confuse programme for data analysis with method of analysis: SPSS, XLS and other data diagnostic programmes are not methods of analysis; rather they are platforms in which data analysis can be done.

- Univariate: these methods include qualitative distributions (age of companies, of innovators) and the range, spread and standard deviations of single factors enabling in-factor comparisons.
- Bivariate methods include descriptive and comparative graphics and tables showing the relationships between two factors (figure-6.1) is an example showing age of innovator and age of company)
- Multivariate methods include correlations and regressions between sets of three or more factors.

Where possible, as chapter-4 illustrates qualitative statistics are chosen in the form of graphs and tables to present data from the survey, the result of which are analysed later in chapter 6.

4.6.4.3 Validity of the Survey Design

Section 4.6.3.4 below reviews the validity of this whole research exercise; here the focus is on the validity of the data from the survey; without validity as Straub et al (2004:8) notes the survey has no standing. Given the gaps in empirical research about UAE innovative technologies in general and the innovation ecosystem system, accumulating data from twenty-seven companies (providing it is successfully published) appears a worthy achievement. Content validity or fitness-for-purpose of the survey instruments, as Rubio et al (2003) note if misconceived makes the research useless. Here content validity of the questionnaire was assessed at pilot stage and found acceptable as did the respondents who saw its relevance and completed it. Of the twenty-seven completions, ten have asked for a summary of the results, again suggesting content validity. Presentation in Chapter 4 informing analysis in chapter 6, further suggest a suitable standard of content validity. These chapters also support construct validity in that metrics are identified and prove useful in analysis: the survey appears to pass Stangor's

(2007:92) standard that the instrument measures the conceptual factor in an analytically useful manner.

From the viewpoint of consistency over repeated use (Eagly and Chaiken, 1993) the results suggest that sixty respondents interpreted the survey instrument in a consistent manner. There are no outliers or unexpected results, suggesting that had the exercise been repeated, then the results wouldtd have been similar.
Chapter 6 presents the survey data analysed for statistical significance, this is then contrasted with the qualitative data from interviews in Chapter 5 and analysed in relation to previous research literature in Chapter 7.

4.6.4.4 Research Validity

Science evolves Chalmers (1982) argues by accumulating evidence, suggesting new theorisations, and testing theory as a guide to practice: in Avicenna's terms positing justified, true belief and then (citing Popper 1989) inviting falsification. Knowledge then is provisional and never absolute truth. As Cohen et al (2006:6) points out, constructivist research can never claim validity in the sense of absolute truth in all places and for all time; validity in social research is better framed in terms of usefulness in understanding specific situations. This research's useful is the result of internal validity (robust method) and external validity (a persuasive explanation of the current nature and dynamics of UAE's innovation ecosystem).

Situatedness is quite different from relativism; the post-modernist perspective attributing as truth however an individual interprets it: this in Avicenna's view would be a belief without being justified or true (in the eyes of others). Situated validity as Silverman (2007) argues, where based on robust method, may have validity beyond the situated origins of the research, when metaphors, concepts and/or frameworks can usefully guide research or actions elsewhere. Feyerabend's (1975) *Against Method* is not against method his point is that internal validity is no guarantee of external validity in other research settings or fields: the final test of plausibility is the ability to help explain social realities. Implausible research falls at this hurdle, hence Samuelson quip that Economists have predicted thirteen of the last five recessions. Usefulness (implying trustworthiness i.e. internal validity) Riessman (2008) argues is the strongest validity social research can claim; here he is echoing Bush (2003) and Elliot's (2005) recommendations. Internal validity alone, however long, and robust the method is insufficient. Many commentators suggest this is the position of Economics research (Bassey 1995; EMH, Arthur 2015), a criticism strengthened by the failure of economists to prepare for the 2008 recession (Wren-Lewis 2018).

Unless research results in an enhanced the ability to understand and explain social reality, however situated, and confined, its validity is questionable. Of course, economists and other may claim that basic research has a longer timeframe in which to establish this ability to contribute towards understanding; an argument Gilbert (2008) considers, however, he then concludes that the onus is on the researchers to point towards pathways along which basic research can have applied research usefulness or alternative he asks, why should society fund such research? Taking an alternative tack, Mishler (1990) argues that though internal validity may be a low standard, it is superior to no standard at all. Like Lukes (1974) he is concerned that social scientists cannot achieve the validity (in terms of causal relationships) that physical scientists achieve; what Lukes terms *physics envy*.

This research has sufficient internal validity (robust and justified method) and is sufficiently useful for understanding UAE's innovation ecosystem (even if later superseded by superior or new research) to have external validity. It can therefore in Hamersley's (1992) terms be termed scientific.

One response to the validity/truth issue proposed by Lincoln and Guba (1985) is to use alternative terminology such as credibility, transferability, dependability, and confirmability, however, terminological manipulation cannot address the substantive methodological issue that research is somewhere on a continuum between provably false and demonstrated truth, with useful validity at a point between these polar opposites. Proposing that this research has validity in the sense of usefulness joins a notable list of researchers making similar claims including Foucault (1972), Putnam (1981) and more recently Wright (2009) each of whom argue that truth hood is unachievable and usefulness the best validity possible. Usefulness as validity is itself a matter of degree depending on the extent to which the research's use can to generalised.

4.6.4.5 Research Generalisation

Having followed Nicholson *et al*'s advice on setting out research conclusions and Charmaz's (2019) notion of a framework-2 encapsulating theoretical contribution, we note Llewellyn's' (2002) advice and carefully portray the conclusions are intermediate theory, generalisable only after recontextualisation. UAE's innovation ecosystem is evolving in a particular culture and context characterised (Chapter-1) by rapidly changing institutions, the ambition of joining the elite group of sustainably developed countries based upon diversification from oil and success in knowledge-intensive, internationalised economic sectors: this is captured in *Vision 2030* promoted by the UAE Government. UAE's culture and context for innovation is influenced by is (Arab, Islamic, trading, oil) heritage and therefore faces unique opportunities and challenges. It is not possible as Alasuutari (1995) suggests simply extrapolate from data, what level of generalisability research has. Firstly, since targets for generalisation alter. For example, this research may have more relevance in Saudi Arabia than South Africa. Secondly, any situated research requires recontextualization before 'lessons' migrate across borders. For example, targeting knowledge-based innovative sectors might be a similar goal in (say) oil-rich Kazakhstan, however the university and R&D networks may be quite different, making generalisation to Kazakhstan only possible if these differences are considered. Carefully recontextualised this research may resonate in other rapidly diversifying economies and countries rapidly creating international standard business institutions. Yin (1994) points out that a robust theoretical framework may be adaptable elsewhere and limits cannot be set by the researcher, instead subsequent researchers will decide what can and cannot be generalised.

4.7 Research Ethics

As in any interactions with other people how one's conduct influences trust and trustworthiness (Six); this is especially so in research where, as Gunter (2012) points out, without integrity in the process, the outcomes are valueless. Ethics therefore is an alignment of intention and behaviour standards: the researcher's integrity, ethical approval by the University of Salford and compliance with ethical codes applicable in the target social context. Cohen *et al* (2006) draw a parallel with policing: unethically gathered evidencing becomes inadmissible.

The University of Salford Ethics Committee approved this non-interventionist research (see Appendix; in compliance with which and following Oakley’s (1999) advice, each survey and interview respondent featured in this research was informed about its purpose, guaranteed anonymity, that personal data would not be stored or shared, gave written consent to participate and was informed that at any point they could withdraw without giving reasons. In the case of survey respondents, they were offered a summary of the results and each interviewee was given the opportunity to check the veracity of their transcribed (and translated) comments. As Clandinin and Connelly (2000) recommends, the researcher accepted a duty of care in relation to each respondent and their data: no personal data will be stored on Salford University’s ICT system or the researcher’s own system. The researcher was genuinely grateful to each respondent and made this very clear.

Conclusion

This section has justified methodological choices for this research against alternatives and in relation to research literature. In summary, a realist ontological perspective and socially constructivist epistemological stance will support the use of mixed qualitative and quantitative method, for research the unit of analysis of which is the innovation ecosystem in UAE. Data gathered will be presented as a case study of the ecosystem, analysed abductively, structured by a research design based on an initial framework derived from previous research resulting in a second framework embedding the results of this research following Charmaz’s (2008) constructed grounded theory research strategy and Nicholson *et al’s* (2018) notion of new analytical framework as research contribution (see table-4.3).

Data gathered	Who and designation	Data designation	Analysis approach
Activities and functions	Survey of 27 innovative companies	Quantitative	Statistical analysis using Survey Monkey & Excel
Narratives, relationships	Interviews with policymakers and incubation managers	Qualitative	Coded (NVivo)
Khalifa Fund responses	Interviews with leaders of KF	Qualitative	Coded (NVivo)

Table 4.3: Summary of data gathered, respondent designations and analysis method

CHAPTER 5: UAE'S INNOVATION ECOSYSTEM – QUALITATIVE EVIDENCE

Introduction

This chapter demonstrates the results of interviewing policy makers and executives of Khalifa fund. It helps answering the second sub-question; "*How policymakers and entrepreneurs perceive that the challenges facing the innovation ecosystem in the UAE* by assembling the qualitative evidence gathered in this research. In doing so, it highlights the key factors that shape the knowledge-based innovation ecosystems as perceived the policy makers and contrasts them with the list of 43 factors found in the literature and developed in the initial framework 1 (see Figure 3.2). This chapter in part meets the fourth objective of this research of offering a deep understanding of the cultural and contextual factors that enhances the innovation ecosystem in the UAE. This is the primary data used inthis research. The following chapter, a quantitative survey of 60 companies, is used mainly to support or challenge the presence of the 43-factors constituting an innovative economy. In short, as the Methods chapter noted, although mixed in methods, it is the qualitative data in this chapter that forms the main evidence trail of this research.

The data for this chapter is the results of analysing twenty-one interview transcripts. It offers another step forward towards theory building and to understand the social construction of these factors from the policymaker's perspectives. As demonstrated in Section 4.5, the researcher has followed in three steps to collect his data.

- Firstly, reporting the results of interviews with the twenty-one Government Officials and incubation managers as shown in Table 4.3. A selection of the transcripts of these interviews is given in Appendix B.
- Secondly, in doing so, to compare and contrast the results of qualitative data gathered, with the quantitative data from Chapter-6.
- Thirdly, after summarising evidence of movement towards a sustainable innovation ecosystem, referencing the 43-factors, this research compares and contrast the views of practitioners (Government and incubation), with those of the Khalifa Fund leaders – the UAE's principal business development agency.

Following these three steps, Chapter 7 then re-integrates this research with previous research and in doing so clearly identifies the contribution from this research. As mentioned in section-4.5, there is no neutral ‘facts speak for themselves’ approach to qualitative research: the ‘facts’ that are selected for presentation and how they are interpreted are social constructions. In this case, the framework developed in Chapter 3 offers a clear structure within which to present data. Evidence for these themes was gathered from the policymakers and the innovators perspectives to build a systemic rich view of the innovation ecosystems. The themes are as follows.

- Innovator/entrepreneur agency and activity
- Firm legitimacy
- Marshalling resources
- Knowledge flow activity
- UAE institutions
- Interactivity in complex ecosystem
- Meta-economic trends related UAE’s changing technological ecosystem
- Meta-economic governances related UAE’s changing technological ecosystem
- Contrast with KF interviews
- Conclusions

Direct quotations from respondents are shown in *italics*. As indicated in Table-4.1, individual respondents are anonymised and coded as R-1, R-2 … R-21 etc.

5.1 Innovator/entrepreneur agency and activity

From Table 3.4 the factors relating to active agency by innovators and entrepreneurs are show in table 5.1: it is evidence (or absence of evidence) of these factors that this section explores.

Unsurprisingly, prominent amongst the factors figure 3.2 encompasses as supporting sustainable knowledge-based innovation is leadership: factors 5, 6, 16 and 27 refer directly to this. Taking the R-10 as an example, R-10 emphasises that innovator may be old or young, students or experienced researchers; he says, “*there is no difference in dealing with either group”.* Also clear from interviewee comments is the need to incentivise innovators, as R-17 says, “*A clear system and policy of the University have* *been put in place allowing the inventor to benefit from his invention should it generate a return"*. R-1 notes their support for those innovators with perseverance, arguing that "*Some of them lose their enthusiasm from the very beginning while others continue to look at the results and may wish to return to the project"*.

Innovator/ entrepreneur/agent i.e. the agent as active innovator			
	Factors	**Function in innovation ecosystem**	**Activity in innovation ecosystem**
5	Business led incubation facilities	Practical help and support	Innovator refines product idea
6	Business support staff	Practical help and support	Innovator learns about business
8	Proof of concept support	Practical product development	Legitimised product idea
10	Product and its R&D	Continuous product refinement	Product alters with customers
11	Process technology	Productivity improvements	Learning to reduce costs
16	Leadership	Entrepreneur legitimised in ecosystem	Entrepreneur's decisions building firm
27	Business networks, customer voice	Grounds product with market/customers	Ideas for user/market-led innovation
30	ICT infrastructure	Proprietary inclusive systems	Easy communications and searches
31	Regulations: IP, Tax	Clear rules-of-the-game	Planning easier with certainties
32	Logistics infrastructure	Cluster-benefits: service specialisation	Shape services to meet needs/ options
33	Rule of law/no corruption	Stability	Legitimacy within legal framework
38	Clear international standards	Ecosystem a compliant partner	Eases international market access

Table 5.1: Factors in framework related to innovator/entrepreneur agency

Active agency, by innovators/entrepreneurs is highlighted as important by interviewees, who go on to note that the successful innovator purposively seeks a technically and financially successful product: factors 8 and 10 in figure 3.2 emphasise this point. R-11 notes that funding support is only available where innovations have a route to market: "*Recommending the support of applicable research as needed by the market through a grant or by way of funding"* and R-15 emphasises innovative technologies with patentable potential. He says, "*Awareness programs for universities and applied institutes to introduce steps to document intellectual property rights"* and suggests support is only available to "*support innovative technological ideas and research projects"*. Universities too filter research projects to identify those with commercialisation potential. R-17 suggests they focus on "*the receipt of the inventions* *of researchers (be they students or professors) on the basis of such research being submitted to the university for registration in terms of evaluation and patenting".*

Active agency occurs in a context, within which as factors 11, 30, 31, 32, 33 in figure 3.2 suggest the innovator navigates towards success. For R-3, suggests supporting only capable innovators using the "*financial policies in the program"*. An important aspect of innovator success, R-6 form the International Policies and International Organizations Administration is early internationalisation and for R-16 project management ability.

R-21, who is closely involved in KF's operations bemoans the size and quality of UAE's innovator pipeline.

> *It is inadequate. Currently, government jobs are important to youth as they graduate from university, which is proof that entrepreneurship concepts and the development of innovative ideas aren't absorbed through school and university attendance, which would have given the youth the ability to transfer these ideas and take them to the stage of implementation.*

He goes on to suggest that too many innovators seek to establish life-style businesses, which are risk averse.

> *"Yes, there is such a concern because Khalifa Fund aims at the growth of these companies to become international companies".*

R-20 and R-21 are less satisfied, depending on their own perceptions without a sufficient market analysis.

> *"Yes, there is a risk that the project might not be completed if the project owner relies on himself in developing the product or the service, market changes must be kept up with and a field study about the state of the market as well as its need of the products or services shall be conducted. Based on this study, the project owner will proceed to develop his services".* (R-21)

KF leaders seem satisfied that every incubating company gets mentoring support. They agreed with the implicit criticism (section-6.1) of the online toolkit, explaining that:

> *"The SME toolkit was closed by the international company in charge of it, and its ownership was transferred to Khalifa Fund. Currently, it is being improved and developed to match the standard required for the support of entrepreneurship".* (R-21)

The KF leaders point to innovation success, R-21 says; "*Our goal for 2018 is 80 innovative projects and ideas - and we hope that 80% of these projects will succeed*". They note that, "*Some government legislation has changed that has a negative impact*", citing Tadweer company fees making recycling innovations more difficult. Unlike innovators, incubation managers and officials, KF leaders view the innovator pipeline as problematic. By way of summary, table 5.2 gathers evidence from both the interviews and the chapter-6 survey of companies relating to innovator/entrepreneur agency.

To summarise, table 5.2 gathers evidence from this section relating to the presence of factors related to innovator/entrepreneur agency in the survey results. Both quantitative evidence from chapter-6 and interviewee evidence from this section support the existence of the factors shown as present in the UAE. Whereas the survey of companies is necessarily trawling the views of companies that have successfully launched, the policymaker stresses the wider point, that many of the launched companies have done so with direct or indirect public support – many innovators lack private investment or strong trading or R&D relationships with private companies.

	Innovator/entrepreneur factors	Evidence
5	Business led incubation facilities	R-11 and R15 note incubates must have a business plan, route to market
8	Proof of concept support	R-3 and R-6 emphasise the ability of innovators to lead incubation processes
10	Product and its R&D	R-15 and R-17 emphasise applied research and trawling for commercialisable research
16	Leadership	R-10 and R-17 evidence success support innovators starting up companies

Table 5.2: Summary of qualitative evidence of factors in framework related to innovator/entrepreneur agency

5.2 Firm legitimacy

Figure 3.2 shows a range of factors constituting the legitimacy of firms: legitimacy as partners, legal entities, suppliers, and customers: forming reputational capital; these are extracted into table 5.3. This section explores evidence from interviews and then incorporates evidence from the survey on the extent to which interviewees recognise these factors as present in UAE's changing innovation ecosystem. Two key themes emerge from coding associated with legitimacy: firstly, image or branding in the eyes of others, represented in factors 1, 4, 20 and 24; and secondly, capability to do business with – represented by factors 9, 15, 28 and 35.

Legitimacy supports firm growth, building the capabilities to overcome newness. R-15 points to the difficulties Emirati firms face launching new products in the face of international competition in home markets: “*Lack of market demand for the product or service and its high cost. Availability of a similar product or service with a lower price in the market”*.

Legitimacy			
	Factors	**Function in innovation ecosystem**	**Activity in innovation ecosystem**
1	Online presence + tools	ES provides problem-solving	Business planning
4	Linkages to MoU agencies	Ready-made network	Network building - legitimacy
6	Business support staff	Practical help and support	Innovator learns about business
9	Market entry and growth	Signposts/pathways to market	Legitimated sales
15	Supply + logistics	Supply-function externalities	Ready-make logistics lower costs/ risks
20	Reputational capital	Trust: reduced transaction costs	Deepening partnerships
24	Media representation	High social/self-esteem of entrepreneurs	Innovator legitimate
27	Business networks, customer voice	Grounds product with market/customers	Ideas for user/market-led innovation
28	Entrepreneurs’ Legitimacy	Network-effect from more members	Benefits from trust/transaction costs
32	Logistics infrastructure	Cluster-benefits: service specialisation	Shape services to meet needs/options
38	F38: Clear international standards	Ecosystem a compliant partner	Eases international market access

Table 5.3: Factors in framework related – qualitative evidence of firm legitimacy

For R-17 the difficulty is connecting research with product development, he says, “*The universities work in the spirit of the old universities and focus on teaching, while they are required to enter the field of research and have a role in the vision of the UAE where it wants to be a pioneer in innovation as universities play a key role in this area”*. Numerous interviewees pick up this theme and in particular comment upon entry into incubation. R-17, for example points to a university bias towards research rather than product development.

> *"The University's policy is to deal with intellectual property, which defines the relationship between academics and researchers and the relationship between researchers at the university. As for this unit, we are working on evaluating it and this process is based in several stages: The initial evaluation, when receiving the idea via the completion of the Invention Disclosure Form, - and then considering the idea and how to develop it in order to produce a marketing concept".*

When asked to give a commercialisation success story, experience such as this led most interviewees to flounder. R-11, for example, comments that "*All projects are under implementation* and R-17 that he was relatively new in the role, but was sure successes exist and *an integral part of the university's structure (as this is part of the strategy towards building a knowledge economy".* One interviewee, R-17 pointed to,

> *"A project with the Ministry of the Environment, where the research continued very successfully for between a year and a half or two years. The results were very satisfactory. In less than two years, the research reached the USA, and we were able to help the researcher achieve a large part of the project in Japan. It proved very successful. In August, the first experiment for this project will be launched commercially and we will start looking at obtaining its commercial license".*

In summary, while many interviewees point to difficulties bridging the gap between university R&D and products and creating legitimacy, most also have difficulty pointing to successful Emirati examples of the gap being bridged.

Legitimacy in the eyes of others, particular business partners appear as image or branding appears more readily achieved. From R-1 is able to point to prestigious networking.

> *In University, most of the scientific research carried out by students and professors depends on government support (up to 80 - 90%). At University, we try to change the community and its systems so that investors can share in the research. My point of view is that science and knowledge do not develop without support from the private sector. It also started with a partnership with MIT, which relies on the private sector for its research. We are trying to apply this system in the UAE, and, to a great extent, we have succeeded. In the past 10 years Masdar has succeeded in financing its projects through several bodies within the country (not just the government), with expenditure totalling approximately USD 60 million or more".*

In highlighting greater success in public sector and not private sector international R&D networking, R-1 highlights a major challenge. He points out that the 'success' story about recycling cooking oil (mentioned above) was funded by *Tadweer* a UAE

Government agency as was the patent registration. His view, also expressed by other interviewees is that there are simply too few good Emirati R&D projects capable of resulting in new products, "*A Scarcity of research and innovative projects".*

76% of companies believe that publicity has helped growth, indicating a B2C focus on sales. Emirati potential spinouts seem capable of creating legitimacy with other public sector institutions in the (non-oil) fields investigated by this research, including international reputable public sector partners, such as MIT. However, the pipeline of projects appears shallow and legitimacy with private sector partners, is limited and there is no evidence of UAE legitimacy and involvement in private sector R&D networks and therefore lack of reputational capital.

R-21 reveals that as overseers of UAE's innovation system, the KF leaders take an international perspective on firm legitimacy. They insist, says R-22 that supported firms adopt international *accounting, auditing and quality standards* and cooperate closely in benchmarking with GEM and OECD, rejecting any criticism (by 30% of firms in survey) that IP law is a hinderance and arguing that "*In UAE Intellectual Property Law is applied in line with international laws for intellectual property. However, it is possible that there may be a delay in taking appropriate measures".* KF's main concern, however, is that innovator firms have the absorptive capacity to operate internationally.

> *This was the reason for recently establishing the Khalifa Fund for Innovation, in order to benefit from these activities and raise the level of support for these fields in the local sectors mentioned. The Innovation and External Projects Department was established for the same reason".* (R-21)

It appears they share the frustrations expressed by R-11 interviewees (see also figure 6.14) at relatively low levels of international sales and firm involvement in international knowledge networks developing new products.

To summarise and integrate with Chapter 6, table 5.4 gathers the evidence from qualitative interviews relating to firm legitimacy in the UAE's innovation ecosystem. UAE innovative firms are achieving legitimacy being established companies with products in advanced sectors. However, this legitimacy may be weaker in the eyes of international customers and competitor or potential collaborator companies. The acid test of capability to do business with are deep R&D relationships and international sales; UAE firms have yet to pass these legitimacy tests.

	Firm legitimacy factors	Evidence on firm legitimacy
1	Online presence + tools	Online presence appears strong; may not be as strong in actual trading
4	Linkages to MoU agencies	R-17 and others point to lack of applied R&D in UAE universities
9	Market entry and growth	R-15 points to stiff competition in international product markets
20	Reputational capital	R-11 and R-17's comments suggest UAE innovative firm reputations are confined to within UAE and not in international markets. R-1 points to UAE's success branding itself as centre for innovation
28	Entrepreneurs' Legitimacy	In eyes of staff, customers, suppliers, banks etc entrepreneur legitimate R-17's point about little applied R&D in UAE universities may detract from Emirati innovators legitimacy in international R&D networks

Table 5.4: Summary of question evidence of factors in framework related to firm legitimacy

5.3 Marshalling resources

From the 43-factors constituting successful transition towards a sustainable innovation-based economy shown in figure-3.1, table -5.5 extracts those relating to resource marshalling. This is gaining control (if not ownership) of those resources (financial, technical) necessary for the firm to launch and grow. As knowledge-based businesses coding shows that the principal resources are people and finance: the former embodying capabilities and the latter the ability to assemble capacity.

Marshalled resources			
	Factors	Function in innovation ecosystem	Activity in innovation ecosystem
3	Fund and partners	Helps marshal resources	Access resources (funds)
12	Risk capital access/structures/exit	Investment cycle benefits all	Firm marshal's start-up/growth resources
13	Leverage, bank facilities	Provides working capital	Bank leverages firm's capital
14	Costs and their control	Diffusion of cost-saving ideas	Entrepreneur can reduce process costs
17	Staff and partners	Pool of staff/partners in system	Recruitment/partnering made easier

31	Regulations: IP, Tax	Clear rules-of-the-game	Planning easier with certainties
36	Effective labour markets	Pool of potential (qualified) staff	Flexible: hours/jobs/workplace
37	Open expert migration	Internationally mobile labour available	Hire + transfer absorptive capacity

Table 5.5: Factors in framework related to marshalling resources to innovate – qualitative evidence

Sub-codes emerging from interviews show three themes or lens through which to explore the capability of innovators: incubation processes, business-building, and knowledge exploitation.

Many of the comments around incubation relate to its aims and processes and not to outcomes in the form of successfully trading companies with innovative products. For example, R-16 stresses the intermediate goal of patenting: "*There is a service for registering patents in which the university pays all expenses*". This theme is echoed by R-17 who says,

> *The protection of intellectual property, and the establishment of outlets and systems in order to find commercial applications for these inventions, so as to benefit the community in the UAE first and foremost - and then the region (and the world) if possible".*

Taking a wider perspective, R-11, too does not view the outcome of incubation in business terms: "*A grant is presented at the beginning of the research to complete the project prototype; Consulting services Paying the cost of documenting the intellectual property rights (divided between the Centre and the project owner)*". Similarly, R-17 says; "*Yes, there are exit criteria, but it depends on the University's need for research. A researcher may be committed to paying the expenses incurred on the project in the event of his abandoning it".*

A second perspective on capability and incubation is knowledge transfer of applied research. For example, R-1 comments:

> *Research should be undertaken by university students, for whom research is compulsory. After the research has been prepared by the students, these are examined and then discussed with the relevant government agencies that can benefit from such research. The research is selected based on several factors,*

the most important of which is, whether it is possible to apply such research in the country, as well as on the experience of the applicant. The transfer of scientific research and innovative projects from the research stage to the implementation stage, so as to contribute to raising intellectual, value added and economic contributions by supporting and developing innovative scientific projects".

He speaks of a direct pathway to commercialisation of research using the Khalifa Fund:

Usually, an amount is allocated for the students of Master's and Doctorate degrees to work on and develop research. After the completion of the research project, it may require a patent and the university bears this cost. However, if it is possible to develop the idea and to use it to form a successful company, the idea is transferred to the Khalifa Centre for Innovation. If the student contributes to the patent, his name is recorded in the patent rights, and it will possess intellectual property and marketing rights. Usually, the projects of students are marketed to parties who may benefit from such research".

Interviewees taking a knowledge transfer perspective on capability and incubation emphasise the threats from international companies. R-2, from the National Department of Scientific Research fears competition in local UAE markets from international firms.

Foreign companies that impose their market power through innovative products and services. This has an impact on local companies, but locally owned companies do not have a significant impact on the economy as a whole, due to the periodic weak development of their products".

From the same Department, R-8 suggests foreign competition is particularly acute in the advanced technological areas targeted by UAE's *2030 Vision*, saying: "*Lack of experience in the advanced sectors and shortage of adequate centres which are needed in order to support research in said advanced sectors".* In similar vein, R-7 argues, "*Some companies have the ability and experience to study foreign markets and identify the most suitable market for them - while some do not have this kind of expertise with which to enter global markets".*

R-6 finds incubation capability challenged by an inability to join international logistics networks: "*This is at unacceptable levels because of the small number of companies that have established systems for outsourced supplier networks in the advanced sectors".* Speaking as some who represents UAE at international trade events, he suggests that "*There are no examples* [of successful incubation] *that can be mentioned relating to the advanced sectors".* Going on to say, "*The best performance is achieved in carbon* *projects, but only in publicly-owned projects such as Masdar and later mentioning software in the aviation sector*". He bemoans," *Levels of underperformance are known to occur in Technology and Life Sciences".*

These comments on capability and incubation from a patenting and secondly knowledge transfer viewpoint fail to emphasise that marshalling resources behind incubation has the goal of successfully trading businesses as an outcome. Other interviewees emphasise business outcomes. For example, R-15 describes incubation activity as:

> *"The on-going development of the product or service supports the continuity of the project and its international emergence through strategic plans for research and development that should be mentioned in the establishment of the project … and getting to know if the external market has a need for such a service or product".*

Both *a R&D plan and market objectives* he says should feature in incubation. He goes on to talk about products being "*constantly updated and developed to ensure its continued international expansion and market need".*

To summarise, the evidence from interviews with innovative UAE firms using advanced technologies shows them capable of marshalling the talent and building the organisations necessary to successfully incubate and begin trading. There is less emphasis on creating successful (profitable) businesses; indeed, no firm and no Official can point to significant market success.

Resource marshalling also relates to gathering the financial resources, including capital and relationships with suppliers and distributors. R-4 is clear about the UAE Government's intentions.

> *"This sector supports entrepreneurship through low interest loans and free advisory services, but there are institutions such as the Mohammed bin Rashid Foundation in Dubai and the Khalifa Fund in Abu Dhabi which provide support. There are also new institutions such as the Emirates Industrial Bank who also supports entrepreneurship through interest-free loans".*

R-4 says *has a vision to support innovation, small and medium enterprises, increase the contribution of small and medium-sized companies in the non-oil GDP of the UAE as well as to raise the quality of innovative companies.* His view is echoed by R-3, from the Finance Ministry, who says, "*This took effect after the issue of Resolution No. 2 of*

2014 regarding supporting small and medium-sized companies, which clarifies all the policies and frameworks intended to help in supporting small and medium enterprises".

There is then a clear policy perspective to finance innovative SMEs in advanced sectors. However, R-3 goes on to say that the main barrier to creating indigenous advanced sectors such as biotechnology, software, and non-carbon companies are *Lack of research in advanced sectors and difficulty in execution due to higher production cost.* R-4 too is careful not to confuse Government support with private investment. He says,

> *"In any bank in the world (not only in the UAE), but banks also have a purely commercial orientation. The basis for financing companies lies on the budget and strength of the company. What is important is that (not only in the UAE but in any bank in the world), this support should include the government's intervention - or private investment. For example, companies owned by citizens and managed by them receive more support from the commercial banks".*

R-5, also points to barriers facing UAE advanced sector companies:

> *"Lack of experience and lack of financial support, but for new companies few of them can withstand the onslaught of the first 3 or 4 years and succeed (and then their quantities will be lower). However, many of them do not succeed - for several reasons - and there is one reason no one can control: competition from international companies and long-established companies. Nevertheless, in my view, the UAE has strong policies in terms of support for emerging companies at the local level".*

The careful view of Officials then is that establishing companies with public support is an insufficient condition for them to compete international.

R-21 suggests that public bodies have a limited role in financing business start-ups. He suggests that the survey figure of two-thirds of innovators using their own capital far from being a problem test:

> *"the commitment of the project owner in will implementing his project, the fund asks project owners whose projects were approved to finance their projects to the extent of 20% of the total project capital (as a guarantee that the project owner is interested and serious about implementing the project)".*

(R-21) that banks and venture funds can be reluctant to invest, however they suggest that good projects will attract funding.

> *"This matter depends on the companies' ability to get funding from banks and funding support. There is somewhat of a difficulty because of the terms and conditions on the part of the banks, and the banks' dearth of programs that support innovative projects or entrepreneurship. Recently, a partnership was*

> *concluded between Khalifa Fund and another bank in order to develop a program which will support entrepreneurship".* (R-21)

KF leaders then appear content at the financial resources available to innovators. They are less sanguine about other support resources, pointing to difficulties in recruiting business development staff with technical expertise across all fields, especially they say non-carbon technologies. Similarly, R-21 argues that while all innovators receive mentoring help (contradicting survey, see figure 6.17) it is difficult to transfer market ad risk analysis "*from the idea-holder to business consultants in order to conduct an accurate study that determines the applicability of the project and the feasibility of supporting it"*. They acknowledge too that professional capable of supporting business innovation.

Notably the KF leaders make no criticism of university incubators being managed by academics rather than businesspeople. While pointing to shortages of business development consultants and some technical mentors, KF leaders appear more content than innovators or incubation mangers with the resources available to innovative start-ups.

Innovators/entrepreneurs focused on their achievements in launching companies a perspective shared by some Officials. However, other Officials are disinclined to focus on inputs and processes and instead focusing on outputs draw attention to the company's inability to succeed in international sales or cement new product development cooperation. Some Officials suggest that UAE universities failure to concentrate on applied research is a major problem, others point to incubation processes led by academics. The marshalling of financial and talent resources to launch companies in advanced sectors is an important achievement. Perhaps only time will tell what extent the companies can survive without publicly funded resourcing.

5.4 Knowledge flow activity

Fifteen of the 43 factors shaping innovation drawn from the literature and gathered in table 3.2 relate to knowledge flows and form one of the major categories in the figure 3.1 framework. These are shown in table 5.7. Coding reveals four sub-themes, which structure this section: (1) tacit/informal flows of knowledge; (2) formal flows: patents, embodied knowledge; (3) people-carried knowledge e.g. visiting staff and (4) organisation-carried knowledge in the form of knowledge management and knowledge network participation.

	Marshalling resources factors	Evidence on resource marshalling
3	Fund and partners	R-17 suggests incubation exit criteria too loose, not business-oriented
12	Risk capital access/structures/exit	R-11 says many firms accessing publicly funded start-up capital
13	Leverage, bank facilities	R-2 notes the success of international companies in advanced sector inside R=4: UAE in competition with UAE companies: without profit projects it is difficult to raise private investment, except perhaps for proof of concept
14	Costs and their control	R-3 and R-4 suggest products launched are insufficiently cost sensitive
17	Staff and partners	Fundamentally, university incubators are not led by businesspeople and often have little interaction with trading businesses
31	Regulations: IP, Tax	R-16 and 17 say university incubators focus on intermediate goals such as patenting rather than outcome goal of successfully traded products R-1 seems to privilege basic research above applied research for UAE universities

Table 5.6: Summary of qualitative evidence of factors in framework related to marshalling resources to innovate

These four sub-themes lend structure to this section, which assembles evidence for the presence or not in UAE innovation processes of the fifteen factors mentioned.

There appears to be a clear difference of emphasis towards tacit knowledge flows between those agents close to innovation and those operating at a policy level. For example, R-10, a Project Manager, who works with individual innovation projects, is categorical that what differentiates successful projects "*is due to the researcher's experience, funding and research results".* He and others stress the importance of lessons gained from experience – tacit learning. Agents further removed from day-to-day innovators place less emphasis on tacit knowledge. R-13 who oversees research partnerships is unworried that there are *No links* between investors and incubates; R-16 however is concerned that *at present* UAE projects have little linkage into international R&D networks. He goes on to note that Government policy seeks to "*support research* *centres and supporting funds and this in itself is a different opportunity".* R-17 who helps manage the Department of Technology, further notes that researchers and incubates have little interaction *with businessmen personally, but with companies that may deal with them.* Formalised knowledge flows rather than informal and tacit knowledge appear most important in UAE's innovation systems.

Knowledge flows			
	Factors	**Function in innovation ecosystem**	**Activity in innovation ecosystem**
2	Links to UILs/SSIs/Firms	Communications platform	Network building - legitimacy
7	Links to firms and mentors	Store of embedded knowledge	Innovator learning
18	Useful knowledge flows	System distributes learning	Entrepreneur learns and benefits
19	Education standards/ staff training	Strong pool of human capital	Staff capable of innovating/growing
21	Business professionals	Pool of embedded knowledge/capability	Firms learns/uses expertise/wisdom
22	Business mentors	Transmission of informal learning	Entrepreneurial learning at lower cost
23	UILs, company R&D links	Links science to technological products	New (potentially disruptive) learning
25	Big company learning	Distribution of spill over learning	Learn best practice for global markets
26	Business mentors	Transmit learning/bond entrepreneurs	Free social/knowledge capital
29	Business professionals	Options for make/buy expertise	Lower start-up/growth costs
30	ICT infrastructure	Proprietary inclusive systems	Easy communications and searches
33	Rule of law/no corruption	Stability	Legitimacy within legal framework
34	Policies: grants, business friendly	Stability and assistance	Access free cashflow + support
35	Exit market	Recycles investment funds	Recapture control of business
39	Routes to connectivity	Ecosystem can fill/create gaps	Ready-made (costly) network available
40	Complementarities	Ecosystem has place in value-chains	Ease of future-proof designs
41	Inward FDI learning opportunities	Transfer technology, knowledge, capital	Knowledge flows: learn from the best
42	Involved in R&D networks	Acceptability in international networks	Join co-design of tomorrow's products
43	Staff with absorptive capacity	Pool of top-level talent	Buy-in absorptive capacity/expertise

Table 5.7: Factors in framework related to knowledge flows and exploitation

Digging deeper, the nature of the formal knowledge flows is revealed as *funding of their research* (R-16), with entry criteria for incubation.

> *… depend on the specific program. For example, in the R&D program, the researcher should be of UAE nationality, and be supported by the university. The exit criteria in the event of withdrawal are that they bear the costs incurred by the research which were financed by the Fund, while in the case of selling the idea or research, the Fund tries to locate a company willing to buy this idea".* (R-16)

Entry criteria are then based on research quality rather than nearness or relevance to market and as R-11 says, there are *No exit criteria*. The goal (R-17) is an *interest at the state level to advance the marketing of inventions with the presence of government support.* Yet the practice revolves around cumulating formal knowledge and not interaction with business opportunities. As R-1 notes, "*Usually, this research is related to a Masters degree or Doctoral thesis. If any of these research projects are cancelled, this also means abandoning the Masters or Doctoral thesis".*

In summary, while there is a clear goal of migrating applied research into innovations, in practice the emphasis at university incubation centres is on formal knowledge rather than the tacit knowledge of how to launch a product or interact with businesspeople. Entry and exit criteria into university incubators lack a clear business focus. One of the simplest ways to transfer knowledge relevant to innovation is people (another way is knowledge embedded in technology). Knowledge transfers, for example, with talented recruits to a company, visiting researchers to a university, innovators interacting with schools. In some of these areas, such as international recruits into university research centres, the UAE invests heavily. Why then does R-6, representing international trade policy, suggest that "*There are levels of under-performance in Technology and Life Sciences* in UAE?"

From the Scientific Research and Curricula, R-2 argues that only *one or two can market knowledge .. other universities cannot.* He suggests that,

> *"in most universities, those who do the research are visitors, not citizens, so how can I fund a research project for a year or two, if it is not Emirati? And it might not be of any benefit after the researcher returns to his country".* (R-2)

His view is the university staff are ill-prepared to deliver Vision 2030: *Yes, but there must be a plan along with the presence of those who follow these actions and who carry out the tasks.* Despite attracting temporary visiting staff, he goes on to state, *there is no international university yet.* Along similar lines, R-16 a programme Manager in R&D,

comments that university commitment to commercialisation is thin, it "*was an idea from a group of Emirati businessmen who aimed to give back to the UAE - also because they did not want to focus on oil, the focus was on research".* Importantly, R-17 notes that *We have no businessmen running the incubator* meaning that knowledge transfer between business and university incubator is limited.

From this it appears that knowledge transfers from abroad by temporarily recruited international researchers are limited and transfers between Emirati business and university incubators is also limited. The key opportunities for people to act as conduits for knowledge transfer appear of limited value in the UAE innovation system.

International partnerships, R-12 from a university commercialisation unit points out, are welcome, however, they can fall short of actual trading links or product development links.

> *"Yes, partnership is a very important part of the management and the way we work. We deal with companies in the United States, including RTI, with German companies such as Fraunhofer, AK in Japan among others - and this is the only way to help us evaluate inventions while marketing them. These partnerships help us not only to evaluate inventions but also to find other companies that may be interested in these inventions".*

R-1 too points to limited partnership arrangements with private companies in discussion how similar UAE incubators are to western incubators.

> *"There are many opportunities in the UAE. The problem lies in the awareness of private companies. The focus of these companies is not on R&D. In terms of the government, everything is available, but the private sector does not invest in the state in a manner appropriate to supporting research".*

That is not to say that Emirati organisations fail to accept the importance of innovation as a motor of change, though as this section will show, there appears to be an over-emphasis on the public sector: the organisations entrusted with supporting innovation are public sector oriented.

Interviewees divide over why indigenous high-tech innovation rates are low in UAE (GEM 2017 suggest only 3% of overall strong TEA rate of 32 per 1,000 population). R-16 for example says that "*The biggest constraint is funding, and some may have a greater ambition than support funds can handle.* Alternatively, R-15 says there is a

Scarcity of innovative projects". No interviewee suggests that an entrepreneurial state might allocate leadership of innovation processes to experienced businesspeople.

There are some linkages, however, these are at a policy level. R-17 points to the close relationship between the Fund, Khalifa Innovation Centre and *one of the banks.* R-14 accepts that no incubation units have links with international R&D networks: *None, but Masdar has a strong relationship with MIT.* From R-16 points to *no success stories to date,* but that the Fund hope to *establish coordination between the Fund and other companies in order to market the idea of the researcher - as well as to work on the subsequent step.*

It is clear that incubation university units in UAE have little deep connectivity with private firms and are not headed by businesspeople. Indeed, according to R-18, the University commercialisation "*organizational structure is divided into two parts: the first is the protection of intellectual property, which is the legal part for registering inventions and entering into agreements - and the second section is there to evaluate and develop the relevant work plan".* Projects are often evaluated at Ministry level, as R-2 notes, "*We hold a weekly meeting for those who apply for projects that contain innovative ideas about universities and schools in Abu Dhabi. We look forward to their presentations and provide feedback on the quality of these projects".*

In summary, knowledge flows concerning innovation are stronger between organisations than with individual businesspersons. As such, they emphasise formal rather than tacit knowledge (including patenting): there is little deep interactivity between incubation units and businesspeople. Innovation project decisions are taken by Ministry Officials or academics: knowledge flows are dominated by the public sector.

To summarise the evidence from this section (see table 5.8), there are sufficient knowledge flows to enable innovators/entrepreneurs to establish businesses in advanced sectors. However, often these knowledge flows are not from UAE universities, who focus on formal knowledge, but instead from imitation (visits abroad) or innovators spotting market gaps. Emirati firms are able to recruit migrant experts and professionals who contribute to company start-up and growth, however, visiting academic researchers appear to have little impact on commercialisable research. Some innovators are able to establish business-based mentoring arrangements, however, mostly these are after incubation; academics leading incubators attach insufficient importance to mentoring links with trading businesses. Those companies able to join international R&D networks may find their membership of new generation product development jeopardised if they have little new knowledge to contribute.

KF leaders point to a university-industry gap; as R-20 notes, "*There are some gaps, for example, there is a difficulty in establishing partnerships with educational institutions in order to design programs to support innovation in schools and universities".* He goes on suggest that applied research by innovators in universities may be insufficiently applied.

> *"In the field of research and development, the matter depends on the owner of the project or idea in developing his own business. The fund has some programs in place that would increase the funding in the event that there is some beneficial study for the expansion of the project".*

> *"Yes, there is a shortage in professional projects. Professional projects depend on educational outputs. The education sector must raise the education level to generate students who can be relied on in the future where professional projects are concerned - for example, Computer engineers or physicians, who may contribute innovative ideas to support the technology sector and life sciences".*

In making these points, in addition to the points above about the reluctance of start-ups to internationalise in sale or joining international knowledge networks, the KF leaders are taking a strategic view of knowledge flows into UAE start-ups and SMEs either from international or university sources. In doing so they highlight an issue hardly mentioned by innovators and only alluded to by officials and incubation managers, yet a key question to which this research will return in the analysis chapter.

Referring back to figure 3.1, 43 factors; (table 5.2; table 5.4; table 5.6 and table 5.8) indicate the preparedness and capability of factors constituting the four major themes: Innovator/entrepreneur agency and activity (section 5.1); firm legitimacy (section 5.2); marshalling of resources (section 5.3; and knowledge flow activity (section 5.4). Interviewees also commented on the three 'wider' themes constituting innovation-readiness: (section 5.5) wider institutional arrangements; (section 5.6) interactivity within the UAE's innovation ecosystem; and (section 5.7) meta-economic trends relating UAE's changing technological ecosystem and their alignment.

	Knowledge flow factors	Evidence of knowledge flows
2	Links to UILs/SSIs/Firms	R-17 incubators led by academics not businesspersons R-2 only a few universities have business orientation + no international university
7	Links to firms and mentors	Links to large companies developed after launch, not before
18	Useful knowledge flows	R-10 suggests UAE universities focused on formal knowledge to exclusion of tacit learning Limited impact of researchers brought from abroad
19	Education standards/ staff training	Q-32 small spend on training; Figure-6.34 recruit highly educated staff R-1 companies able to recruit MSc/PhD trained staff
21	Business professionals	Q-34 ability to recruit and rank professionals
22	Business mentors	Business mentors from public agencies not trading businesses
23	UILs, company R&D links	R-17: links are limited or non-existent R-15 limited array of worthwhile projects (R-16 blames lack of funding)
24	Media representation	R-17 media pictures state support, not private sector support, for innovation
25	Big company learning	R-16 suggests little learning from large companies
33	Rule of law/no corruption	Q-45 IP law adhered to; Q-47 no reports of any corruption 100% agreed no corruption in advanced firms
35	Exit market	Q-21 preference for private sale exit; no UAE formal market R-6 says firms under-performing; no example yet of successful exit
42	Involved in R&D networks	R-16: without knowledge contribution, UAE firms may not hold places in key international R&D networks developing next generation products
43	Staff with absorptive capacity	R-16 foreign staff cannot be grant-holders or lead incubation

Table 5.8: Summary of qualitative evidence of factors in framework related to knowledge flows

5.5 UAE institutions

UAE institutions refers to UAE’s innovation readiness to becoming an entrepreneurial economy: institutional areas within the control or influence of UAE Government and society. Four sub-themes emerged from coding under primary code: (1) finance for innovative companies; (2) young people and their education; (3) state resourcing of support for innovation; and (4) the ability to eliminate institutional barriers – dynamic institutions.

Since knowledge-based companies invariably generate losses prior to becoming income positive and later profitable, they require both bank and venture finance coupled with arrangements whereby funders can exit, often by sale of private equity. Interviewees are aware of this regime from their close observation of US innovation arrangements. A senior Manager from the Arab Bank, R-4 captures the strategy of investing in advanced sectors as follows.

> *"The day will come when oil resources are low, and the problem lies not only in oil resources but in finding alternative sources. From this perspective, we must focus on advanced sectors in order to support the economy and establish companies that will help achieve sustainable growth".*

The Arab Bank has a section dedicated to providing loan-funding for innovative SMEs. He goes on to note the ability to syndicate risk across banks.

> *"All institutions are linked to this strategy, for example the Central Bank and the Union of Banks, all are included in the strategy of the UAE - and this impacts the policies and procedures of banks and the direction of banks relating to investments. One of the directives of the government is to support projects in the sectors of education, health and technology".* (R-4)

Investors often want secure rights over IP, which is regulated in UAE, though as R-4 went on to say, not in ways to inhibit international investment either at start-up or exit stage. As one of the global centres of financial services UAE is well-placed to meet the finance needs of innovative companies, this coupled to Government encouragement to invest suggests that UAE's finance institutions are suitable providers of finance.

Education and the advancement of young people has the support at the highest levels of UAE Government. As R-2 notes, "*According to Sheikh Mohammed bin Zayed, dependence on the state shall not be permanent, we have the ability to invest in the youth so they can ultimately rely on the knowledge-based economy".* On numerous occasions Sheikh Mohammed bin Zayed has stated an unwavering commitment to raising educational standards in UAE to the best international levels.

R-4 points to the over-riding issue of lack of private sector investment and engagement with some publicly funded start-ups.

> *"Only to the private investor, there are many procedures and systems, but there is no support for this area, and there is an approach by the Khalifa Fund and*

> *Emirates Industrial Bank to enter the field of venture capital in order to support new and developing companies or to help provide entry into the stock market. There are also the DED procedures (but not banking procedures), and they have certain conditions for the tracking of companies, so that they can be launched on the stock mark"*

As R-1's and Q-32 responses suggest, Emirati education faces stiff challenges in raising standards to the best international levels. R-2 openly says, *we have not seen any strategic plan in this regard and there is no structure to achieve this.* He goes on,

> *"Most of us do not recognize the real challenges in education. For example, I do an analysis of the periodic assessment of TIMMS, a global assessment of maths and science. When I see the results of the students in Abu Dhabi, I find them amazing, but there is another teacher-related dimension in terms of the student's view of the teacher, how to explain and comment on students' mistakes - results have never been satisfactory. Who is responsible for teachers? Today we are not authorized to publish bad analyses, and in this way, we cannot progress further".*

Though supported to change and improve, schooling then in UAE faces challenges. So too does the higher education sector. National plans insist that education and industrial institutions closely cooperate. For example, R-16 points to "*understanding and clarifying the goal of the Fund for investors and facilitating cooperation between institutions".* Such cooperation is most sharply seen in encouraging applied research and its commercialisation. R-1 is in no doubt that

> *"The UAE can develop a knowledge-based economy. It cannot be achieved in a year or two, but it can be achieved in 5 or even 10 years. It depends on the type of investment used to develop the environment for innovation, which supports these ideas and sciences so that it can become an economic concept and not just research".*

Amongst the examples of support for applied research, R-11 from the Takamol Centre, points to:

> *"The Implementation and Technology Committee that is affiliated to the Applied Technology Institute has been transformed into a Business Incubator with the support of the government, particularly the Department of Economic Development, becoming the Takamol Centre for Innovation which is a government centre affiliated to the Department of Economic Development".*

As a senior figure in the Education and Knowledge, R-2 unequivocally supports applied research.

> *"I am in charge of the education sector. If I go abroad, I find all the research published in the international scientific journals has substance - but eventually, who reads it? The biggest result that the Abu Dhabi site may get is from those who go to the research sector and download all the research, as there are more than 400 research projects (and anyone who wishes to do research on universities, colleges and private schools in the Emirate of Abu Dhabi shall get permission from me personally and will sign a letter to obtain a copy of the research carried out, whether they are inside or outside the country). We have our own system and goals. All the research that goes into education in the Emirate of Abu Dhabi is read only by those who want to do research".*

In summary, there is a clear intention from the highest levels in UAE to improved young peoples' education and support applied research. Unlike other developing economies with similar aspirations, UAE has the resources to support its aspirations. Education institutions then support improved education, a wider socio-cultural question is how much innovative activity by young people does this support result in?

National level commitments to education and innovation institutions are only effective if backed up with resources, in the case of UAE many interviewees follow R-3 in noting that national budget make resources available to achieve strategic objectives: "*The government's allocation of a budget to set aside funds to support entrepreneurship in the country".* In particular he notes that "*Innovative, small and medium enterprises are supported by the Ministry of Economy through participation in exhibitions both inside and outside the country (as a grant towards promoting their projects)".* From the high number of young Emiratis establishing their own business. UAE is able to invest heavily in programmes supporting education and innovation strategies aimed in particular at young people giving it a competitive advantage over other developing states with fewer resources.

In any complex system reverse salient are likely to emerge, acting as barriers to innovation: how able is UAE to alter its institutional arrangements in order to overcome barriers? One potential barrier commented upon by interviewees is internationalisation – an essential move by innovators located in a small market.

R-15 emphasises the experience gained from international interactions.

> *"Overseas, they have centres and incubators who support innovation and who have long-established experience. But in the UAE, all incubators and innovation*

> *centres are modern and need time to gain enough experience to support innovation".*

In similar vein, R-18 from University Department of Technology notes that,

> *"Creativity is a little difficult with a lot of competitors, some companies have different financial resources - and in my view, companies that have achieved global reputation include innovation and creativity in their strategy".*

From the perspective of the Department of Scientific Research, R-1 suggests gaining international experience is encouraged.

> *"There are no restrictions, especially within the university, but there may be some external constraints that affect the marketing of research - associated with approvals from government agencies, which are difficult to access by people concerned with research".*

A senior figure from the International Policies and International Organizations Administration too stresses that *companies supported by Khalifa Fund for Enterprise Development are invited to participate in international events.*

Barriers to international companies and researchers innovating in UAE, R-19 from university suggests are being removed; he points to regulations on IP ownership and recruiting foreign labour. As barriers become apparent, the examples above relating to internationalisation suggest UAE is prepared to remove them.

Following from these points on university-industry links, R-20 focuses on what he sees as a major gap in UAE's innovation ecosystem.

> *"The sustainability of innovation depends on the development of the product. Aside from the innovation, marketing the new products outside the state will ensure the continuity of business. … To create an economy that depends not only on governmental projects but also on diversified income sources in order to contribute to innovation. To add to GDP supporting innovation is an important point - as is shifting innovations from the research phase to the application phase so as for it to be a project that creates job opportunities, thus avoiding relying solely on government jobs".*

Within the overall institutions the KF seeks changes supporting innovative companies. R-21 mentions "*Engaging project owners in local and international exhibitions and lobbying the Ministry of Labour to exempt the owners of start-ups from having to provide a bank guarantee when issuing work permits for employees".*

KF then seeks improvements to existing institutional arrangements for innovation in UAE, however, it is not clear what actions they intend to take to address the commercialisation gap, which itself contributes towards other problems such as membership of international knowledge networks and international sales. R-20's view is that,

> *"University commercialization is weak, but there are partnerships with some universities with awareness programs to instil a culture of entrepreneurship. However, it shall be more feasible to disseminate the culture of entrepreneurship from within the university, through strong links established with educational institutions".*

Is lack of applied research and commercialisation a major problem? R-20 is in no doubt: "*universities must expand their efforts in the field of international research (through which international culture and expertise will be transferred into the country)".*

Potential positive aspects of institutional readiness for sustainable innovation ecosystem	Potential negative aspects of institutional readiness for sustainable innovation ecosystem
• Availability of incubators and risk capital	• Incubators led by academics and at time poorly connected with trading businesses
• Wide availability and high participation in higher education; high rates of women innovators in advanced sectors	• Low rates of international sales and involvement in international new product development networks
• Changing institutions encouraging internationalisation	• Limited university commercialisation and limited applied research

Table 5.9: Summary: qualitative evidence of institutional readiness

One of the remarkable indicators of modernisation in UAE is the high participation rate of young women in higher education (60%) and intention to start their own business (80%); 40% of Emirati women now work. Almost a third of the innovators survey are women. These are represented in non-carbon (30%), life-sciences (12%) and software (50%) reflecting the rising contributions of women in UAE mentioned in sections 1.1 and 2.3; the survey finds women significantly represented amongst Emirati innovators.

By way of summary, the evidence shows UAE institutions, especially education and the availability of risk capital as readily available, distinguishing UAE from developing innovation ecosystems without investment resources. These factors are especially important in supporting young innovators and notably young women innovators. Government funding of incubators and centres, though capable of improvement (especially by introducing more business leadership and connectivity) are available and support two-thirds of the companies surveyed. Perhaps most importantly, this section illustrates the ability of UAE institutions to reform and modernise; they have dynamic capabilities, exampled by institutions altering to strengthen internationalisation – of sales and involvement in knowledge networks.

5.6 Interactivity within a complex ecosystem

How connected and interactive are agents, organisations and institutions constituting UAE's innovation ecosystem? Overall, do the responses of agents to external stimuli and the decisions of other agents result in a thriving, evolving ecosystem or alternatively are their ways in which the innovation ecosystem is atrophying. In coding two sub-themes emerged: firstly, the extent to which agents have a shared destiny or vision of the ecosystem's direction of travel; and secondly, the efficiency with which agents can understand and respond to the actions and interpretations of other agents.

Overwhelmingly the Emiratis interviewed expressed self-confidence, were aware of *Vision* 2030 and felt its goals achievable: there is a perception of shared destiny. For example, R-11 commented that the Vision:

> *"Absolutely realistic due to the diversification of the country's income sources - and not relying on oil as a main source. Supporting innovative projects such as fast-growing technological projects and life sciences which contribute to supporting the country's economy as alternative income sources".*

Another example is R-18 from a university who says,

> *"Yes, it is realistic since all existing studies aim to apply the economy of knowledge. I see UAE at the forefront of many countries, there is a system to provide financially for research opportunities as the UAE government spends generously on research projects. There is also an industrial system and the most important thing to be noted is the availability of human resources, which is the main element in establishing an economy based on knowledge".*

Evidence of agents in the ecosystem responding to the interpretations and actions of other agents is also strong. From the Department of Education and Knowledge, R-1 pointed to links with companies in the form of business-person Advisory Board *provide counselling and support services for students* on incubation and careers. He also noted transferring ideas from international R&D events and exchange *of ideas with other* *universities and access to the latest scientific and global developments - so that we can learn from these experiences.* His view is that learning from international trends and events is embedded into UAE university practice.

R-3 pointed to policy changes in the Department responding to international trends *which the support and financing of small, medium, and innovative institutions is to be implemented.* R-4 gave recent examples of policy changes supporting SMEs.

> *"The government is supportive of new companies. For example, in Abu Dhabi and Dubai, if a new company is established, they are exempted from many fees in the first year or two - and there is a new decree issued for companies by the Ministry of Labour, exempting them from paying bank guarantees for workers".*

He went on to note new tax policies incentivising knowledge-based companies. R-16 noted new partnership arrangements to strengthen incubation centres. From these comments, it seems fair to conclude that agents in the ecosystem are actively responding to events and actions by other agents. R-3 mentions, "*The Ministry of Economy has built relationships with the world's top countries known for supporting small and medium-sized enterprises - such as South Korea, Finland, Japan and Canada".*

> The responsiveness of agents at national level may be more efficient than those at local level. For instance, within incubators R-11 speaking about links to mentoring companies or existing trading companies that there are "*no links - it depends solely on the experience of the work team that is managing the business incubator*. He suggests, "*At present there are only links with universities within the country but in the near future there will be links with international research companies".* R-1 bemoans *no links with investment companies yet* but mentions linkages with large international companies *for example Airbus, Boeing, Earth*. At ground level, in incubators responsiveness to other agents in the ecosystem may be shallower than at national level.

The one organisation to which all agents look to for guidance and support is the Khalifa Fund, which appears to have a pivotal role in leading activities. For example, R-15 speaks of close working between investors and the "*Emirates Development Bank and the Khalifa Fund for Enterprise Development".* He goes on to suggest that KF provides "*Excellent guidance and consulting for projects".* R-1 notes how the KF trawls for relevant research, and oddly, R-2 from the same Department is unaware of interaction between the KF and research activities. R-17 from university says they work closely with the KF though: "*So far there are no success stories with Khalifa Fund, but we are* *working with one another in order to create success stories".* A leading figure from the National Program for Supporting Small, Medium and Innovative Project, R-3, notes that:

> *"The Khalifa Fund for Enterprise Development serves as a member of the Ministry of Economy's National Council for supporting Innovative, Small and Medium Enterprises in order to develop unified policies to support these companies".*

In summary, (see table -5.10), the KF is one of the 'connectors' in UAE's innovation ecosystem, referenced and/or jointly working a wide range of other agents.
Complex ecosystems sustain and evolve due to the speed, quality, and relevance by which agents signal change and interpretations to other active agents in the ecosystem. The degree of self-confidence in the future of Emirati innovators, officials and incubation managers is shown in this section to be extremely high. For example, R-11 and R-1 emphasise the need for greater creativity and more entrepreneurship training in the higher education system.

Though several interviewees (R-1; R-17) cannot point to successes in the incubation system, the fact that ten (38%) of the innovative companies have traded for over 4-years and a remarkable 91% traded more than two years (the GEM standard for sustainable) is itself notable success. Table.510 (below) notes the central role of the Khalifa Fund in driving ecosystem interactivity.

From the perspective of the KF, they note that 100% of firms surveyed know of their activities; "*That's good, but we must keep the development and support in place to guarantee the continuity of business".* They point in general to opportunities facing *innovative ideas that have market value*, however with the qualification that the innovator needs "*full knowledge of how to apply the innovative idea along with its time frame of implementation as a project".* This, however, is the very gap that business mentoring might fill. Their frustration is insufficient ideas and innovators wanting to create *sustainability in the local and international markets.*

Thus, the KF leadership enjoy freedom from political interference and substantial public investment. They appear well-positioned to lead the evolution of the ecosystem, however in two areas of interactivity the ecosystem is somewhat dysfunctional: (a) university-industry links and (b), what R-20 refers to as:

> *"The role of the public in understanding the culture of innovation along with the role of education are both very important in this aspect, in order to achieve the integration phase by implementing innovative concepts along with encouraging pioneering endeavours through education".*

Potential positive interactivity in complex ecosystem for innovation	Potential negative interactivity in complex ecosystem for innovation
• Self-confidence in achieving *Vision 2030*	• At time weak connections between incubators and commercialisation units and business mentors and trading companies
• Innovative firms sustainably trading	• Firms successfully trading, however, largely in (small) UAE markets
• Promoting creativity and entrepreneurship in higher education	• Ecosystem's international interactivity is limited especially internationalisation of students, researchers, and product development projects

Table 5.10: Summary – qualitative evidence of interactivity in complexity

5.7 Meta-innovation trends and UAE's changing innovation ecosystem

Insularity resulting from path-dependency potentially reducing alignment with meta technological and economic trends is a danger facing all innovation ecosystems. How dynamically aligned with these trends is UAE's innovation ecosystem? Without perfect foresight this question is unanswerable, however, it is possible to discern ways in which UAE's innovation ecosystem is adapting with the intention of alignment to meta-trends. The overall dynamic of UAE's innovation ecosystem, as R-4 says, is

> "*related to the first question on oil since it is important that the income of the state does not depend solely on oil. The first thing that helps the tax system is to regulate companies in terms of declaring budgets. This is an additional income and support for the State (and will benefit the economy indirectly)".*

Interviewees share the diversification strategy captured in *Vision 2030*. For R-6 this means concentrating on "*industry, technological projects, clean energy projects, educational projects and the support of scientific research".* R-2's lens is that of education modernisation: "*the evaluation of schools, universities and curricula and submit proposals for modernization";* whereas from Bank perspective alignment according to R-6 involves, "*supporting the state to invest in the more advanced sectors* *through the establishment of support funding"*. He goes on to give examples from UAE's fiscal regime to illustrate alignment with risk capital project funding. R-3's examples of alignment relate to "*The Ministry of Economy is working with the Securities and Commodities Authority (SCA) to enact a law and develop a policy to support small and medium enterprises"*, though he then suggests banks are somewhat risk

Referring to major international technological trends, the KF leaders point to recent initiatives aimed at stimulating international competitiveness of innovative products: *Organizing the international competition for technological projects at the Pitch@Palace AE Event.* They remain of the view, as R-20 says that by the year 2030 UAE's innovation ecosystem,

> *"will be a system that depends on education, culture and government support from legislations and laws related to entrepreneurship and innovation support. This will work as an integrated system that includes the education sector, support funding on the part of financial and government institutions".*

In this they endorse the 100% of innovators, officials and incubation managers who believe that *Vision 2030* will be realised. Self-confidence and a shared destiny vision are clearly important in all radical social change.

Overall, the interviewees accept *Vision 2030* and see UAE's innovation ecosystem changing to align with the needs of advanced sectors such as software, life-science, and non-carbon technologies.

table 5.11 suggests from this data that meta changes in the global economy, impacting on innovation ecosystems may potentially have positive and/or negative effects on UAE's innovation ecosystem.

Potential positive meta-trends impacting emergent UAE innovation ecosystem	**Potential negative meta-trends impacting emergent UAE innovation ecosystem**
• Shared destiny: companies and policymakers share *2030 Vision*	• Comfort of known (oil-economy) risk of unknown: innovation ecosystem
• Oil/gas income may begin to fall, yet still sufficient to fund programmes investing in innovative sectors	• Danger of insularity (chosen target technologies may be disrupted)
• Leverage from UAE as cultural/tourist/ property centre spill-over into technological innovations	• Building knowledge workers from low base (educated workforce, research capability)

Table 5.11: Meta-innovation trends - qualitative evidence related UAE's changing technological ecosystem

These are meta-trends to which UAE's innovation economics can respond, yet like other ecosystems, cannot control: each positive can be amplified, each negative mitigated. In the twelve years to 2030 technologies are likely to dramatically alter; twelve years ago, big-data analytics and home robotics were emerging technologies and are now mature! The point is that what currently appears as a viable innovation ecosystem will only remain so if investment and capabilities successfully address the next generations of technological innovation.

5.8 Meta-governance changes and UAE's changing technological ecosystem

How closely are the governances of UAE's innovation system aligned with emergent trends in technological ecosystems? R-6 argues that global governances are increasingly moving towards a post-carbon future.

> *"To diversify sources of income in order to support the economy of the UAE and to focus on the sectors of education, health, infrastructure, technology, and clean energy (as oil is a temporary, unreliable income source)"*

His college R-6 notes that UAE wants to occupy space (products and technologies) contested by other innovation systems and it faces threats from "*The imposition of taxes and fees by foreign countries and the high cost of production due to the high wages and administrative costs faced by the project"*. The global governances with which UAE is aligning may well be much more competitive that those governances they are leaving behind.

KF leaders are clear that changing the innovation ecosystem requires radical changes in governances, including those mentioned above. R-20 says,

> *"We are finding it difficult to achieve this goal, but we are seeking to reach this goal through our willingness to transform the economy of the UAE into an economy that doesn't rely solely on oil*. He goes on, *it is very important in order to guarantee the continuity of business and increased growth in entrepreneurship - and obtaining innovative projects can be an alternative to oil"*.

Table 5.12 illustrates from the data important ways in which global governances may alter to the benefit or dis-benefit of UAE's innovation ecosystem. Arguably, creating new governances can be easier than altering existing embedded governances.

Potential positive meta governance changes and impact on UAE's innovation ecosystem	Potential negative meta governance changes and impact on UAE's innovation ecosystem
• Building trust-based, replacing rule-based institutions	• Switching from oil-dependency to innovation-dependency governances
• Global governances changing: UAE an actor with influence	• Difficulties sustaining membership of international R&D knowledge networks if little university applied research
• KF and senior officials preparing post-oil governances	• Contested space: international markets in emerging technologies

Table 5.12: Meta-innovation governances and UAE's changing technological ecosystem - qualitative evidence

For innovation ecosystems alignment with emerging technologies and inclusion in the international knowledge networks of firms developing next generation products is key to avoiding insularity: this may be UAE's greatest challenge.

Conclusion

The chapter has presented qualitative data from interviews with twenty-one officials, incubation manager and KF, reflecting on this data, leaving triangulation with previous research literature until chapter-8, with chapter-7 presenting quantitative data from this research. Structured around coding that aligns with factors identified from previous research that are embedded in a new analytical framework (see figure 3.2) the focus is on activities relating to Vision 2030 and the three target technologies software, life-sciences, and non-carbon. Evidence from interviews with leaders of the KF acts as a Delphic panel, as the reflect on the main findings of this research.

The data reveals innovators successfully launching, growing, and sustaining firms in advanced sectors; however, this is with considerable support from public funds. Few disagree with the need to increase the pipeline of innovators, referring to the need for entrepreneurship education in universities. Rates of women innovators are particularly impressive, especially those in advanced sectors, revealing a success of UAE's general culture and higher education system.

Though innovators and firms are legitimate in the eyes of UAE institutions, they lack legitimacy in the eyes of international companies both as trading partners and more especially as partners in the leading product development knowledge networks. Though innovators and many officials fail to recognise this challenge, KF leaders view this as an area requiring attention.

Innovators are able to marshal the financial and other resources necessary to launch and sustain innovative companies, helped by UAE's advanced IP regime and legal structures. Resources for sustainable growth from international connectivity are less available to UAE's innovators and the country's universities officials and incubator managers suggest are insufficiently practice the applied research likely to generate an increased stream of innovations, nor (despite some progress) are the universities internationalised in terms of students, staff, and involvement in international R&D projects. UAE banks and VCs while offering some support to innovators would strengthen the innovation ecosystem by becoming more venturesome.

Knowledge flows into incubators and innovative start-ups have inadequate links with trading businesses, in part perhaps because university incubators are often led by academics rather than businesspeople. Improved flows of tacit learning added to formal knowledge flows may improve start-up rates and rates of internationalisation.

Though a developing ecosystem, UAE is a rich economy, benefiting from substantial investment in institutions, such as education, higher education, and incubators, from its natural resources. In particular, women's contribution to the innovation ecosystem is show in the data to benefit from these institutions. Advanced sector company longevity and good levels of interactivity between agents in the innovation ecosystem, result in an exceptionally high level of self-confidence that UAE can achieve its 2030 Vision. Doing so is likely to require UAE's institutions to act dynamically, embracing future emergent technologies and governances to avoid the danger of insularity; a challenge recognised by some officials and leaders of the KF.

The chapter illustrates differing perspectives between interest groups. Innovators focus on short-term and operational issues, whereas some officials and KF leaders take a longer-term view, some of which (e.g. university applied research; bank risk-aversion) are shared by incubator managers while others are not shared (e.g. business leadership of incubators; company internationalisation).

What then are the ‘big picture’ findings from this empirical research? Firstly, the position of the UAE and its ability to invest in institutions (and infrastructure) supporting an innovation-based economics, is quite different from that of developing economy ecosystems without the flow of investment funds from effectively managed natural resources. Secondly, for a small open economy with a small innovator pipeline international of knowledge flows and sales is critical. One only surveyed company has $10 million turnover, and none appears partner-of-choice in international new product development consortia and learning from large companies. Thirdly, as KF and some officials recognise, significant reforms in the Emirati education system (creativity) and higher education (applied research, internationalisation of staff and research) are necessary, alongside greater preparedness of banks and VCs to offer early-stage risk capital and incubators to create better linkages with trading businesses. Finally, on a positive note, UAE’s ecosystem is generating advanced technology firms with impressive longevity and a high rate in advanced sectors of women innovators.

Having present the primary data from this research, the twenty-one qualitative interviews in this chapter, going a long way to meeting research objective three i.e. a rich picture of UAE innovation and its context and culture, the following chapter presents quantitative data from a survey of twenty-seven companies designed to support or contradict the qualitative evidence in this chapter.

CHAPTER 6 UAE'S INNOVATION ECOSYSTEM – QUANTITATIVE DATA

Introduction

While the previous chapter presents qualitative interview data to interpret the policymakers' view of the key factors that shape the innovation ecosystem, this chapter is outlines the quantitative survey results collected from the start-ups owners; noting that primarily as chapter-4 explained, this is qualitative research. Both chapter-5 and the current chapter reference the factors constituting an innovative ecosystem as drawn from the literature and embedded in the framework (see figure-3.2). Like the previous chapter, data alone is discussed here, leaving triangulation with previous research literature to the following chapter (seven). In total the two chapters meet objective four of this research i.e. building a rich picture of innovation in the UAE and of how the context and culture influences innovation.

This chapter partially answers the first and third research sub-questions, using quantitative data. It also helps examining the extent to which Linstone's (2009) multiple perspectives theory is embedded in the figure-3.2 analytical framework to understand the perceptions of start-ups and significance of the key factors shaping the innovation ecosystem in UAE. The 43 factors were merged under the four headings shown in table 3.4 to allow analysis and categorised using Linstone's TOP approach in figure 3.2. Overall, the figure 3.1 framework was the base for questionnaire design to examine the factors, associated activities and relationships necessary to move towards a sustainable knowledge-based ecosystem, captured in the UAE Government's *Vision 2030*.

As explained in Section 4.5.1, the survey method, the questionnaire design, its piloting, and data-manipulation techniques were followed to reach the findings shown in this chapter. Confidentiality of business matters is a strong culture among Emirati start-ups. Family start-ups considered the research a stranger, so conducting interviews was extremely challenging and collecting a thematic sample was the only choice. This sampling technique was employed in this research resulting in qualifier conditions making the sample typical of innovative companies in the three chosen sectors. So, the eventual sample size was reduced to twenty-seven: eleven software companies, seven life-science companies and nine non-carbon companies.

The sample size is therefore somewhat small, especially in order to retain balance and consists of eleven software companies, seven life-science companies and nine non-carbon companies. To reach this size of sample using the Khalifa Fund database, required considerable follow-up effort and personal contact. The raw data results of the survey, in SurveyMonkey format, are included in Appendix-A.

This chapter follows structure of the analytical framework (figure 3.2).   The first section of this chapter reports innovator/entrepreneur agency and activity. The second section addresses the firm legitimacy towards innovation ecosystem, while the third section explains how important is marshalling resources for the survey participants.

The fourth section explains the results for the knowledge flow activity, while the fifth section points out the key UAE institutions supporting innovation in advanced industrial sectors. The sixth section maps interactivity in UAE's complex innovation ecosystem and the seventh section address the meta-economic trends related UAE's changing technological ecosystem as revealed by innovators surveyed. The last two sections address the meta-economic governances related UAE's changing technological ecosystem as well as summarise the results and indicate how they evidence the 43 factors constituting an innovation system.

6.1 Innovator/entrepreneur agency and activity

Representing the views of twenty-seven innovators in UAE, in answer to the question (Q-65) "*In your opinion, will UAE achieve its vision of becoming a sustainable high-income country"*, all twenty-seven answered the question and all answered positively: 100% of these innovators believe UAE will become a sustainably high-income economy by the year 2030. 96% of innovators are under-50 years of age, with 42% (n=11) under 29 years of age. 29% (n=8) are women – almost one third.

As figure 6.1 illustrates, some companies (8%, n=2) are less than one year old, so still have to pass the test of sustainability after two-years of trading, a test already passed by 21 companies (92%), with a third (36%) over four years of age i.e. firmly established.

ANSWER CHOICES	SCORE	RESPONSES
Less than 1 year	0/2	7.69%
2 to 3 years	1/2	53.85%
✓ 4 to 5 years	2/2	19.23%
✓ Over 5 years	2/2	19.23%
TOTAL		

Figure 6.1: Survey company age

Figure 6.2 illustrates the range of product technologies created and sold by this set of companies.

1	US stock market investment advice
2	Marketing analytics
3	online beauty advice
4	Smart plugs Smartphone control
5	Online wedding planning
6	E-commerce beauty products
7	App control energy use
8	mobile app
9	Blue tongue diagnostics sheep
10	Medical device Combined self diagnostics
11	Incineration Disposal Technology
12	Computer Tablet Mobile
13	Game In-app purchases Mobile
14	solar panels solar batteries
15	App Mobile Tablet
16	AI diagnostics
17	Electricity Solar System
18	Location based solutions
19	Power bank solar
20	With headquarters in UAE and serving regional and global customers, ixtel is a leading digital services company, providing a broad range of services and solutions in Cyber Security, Artificial Intelligence & Robotic Process Automation, Big Data Analytics and Digital Infrastructure Services. We shape our clients' future, combining deep business insight with the understanding of how digital technology will impact industry and business models. Our focus on issues related to digital disruption, redefining competitiveness, operating and business models as well as the workforce of the future helps our clients find future value and growth in a digital world.
21	Solar water cooling
22	Special Needs Portal Special Needs Store Special Needs Software
23	Medical services Occupational health Occupational Medicine
24	Subsurface geophysics aquistion
25	Hiperponic agriculture growing
26	Information technology future
27	Solar

Figure 6.2: Survey company products

Figure 6.3 illustrates the origin of ideas for the main product of these companies.

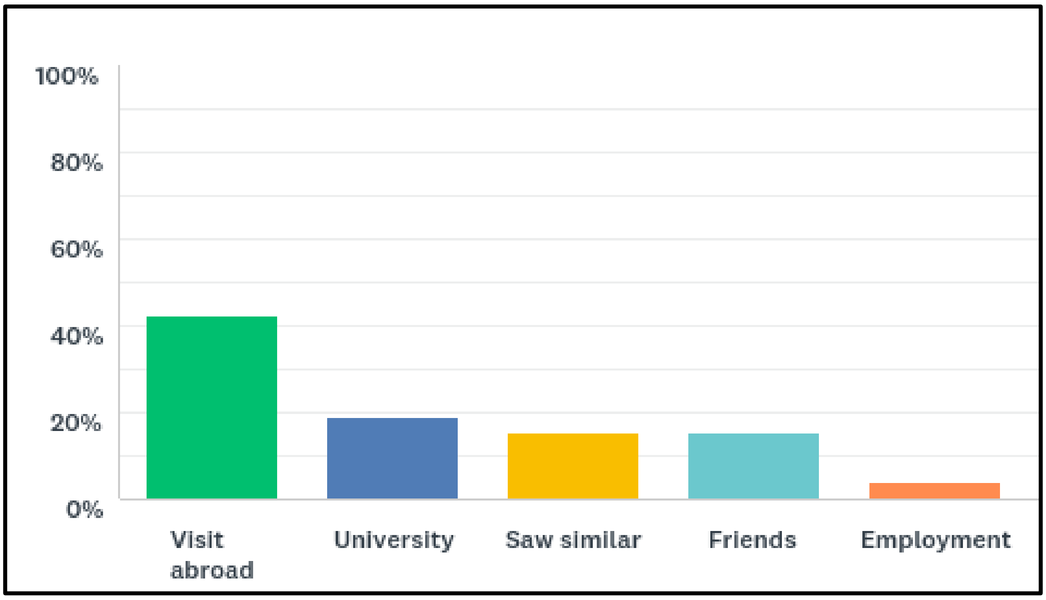


Figure 6.3: Source of main idea for company product

Source of funds for proof of concept are shown in figure 6.4.

Own funds	1/4
Family and friends	2/4
Bank facility	3/4
Loan from entrepreneurship fund	4/4

Figure 6.4: Source funds support company proof of concept

Eight respondents skipped question-12 asking if they used a bank loan to fund proof of concept stage; some of these perhaps because they had alternative sources of funding. Amongst those commenting, two described the banks as "useless." Five respondents said they did not use a bank loan, leaving twelve respondents who typically comment: "slow but positive;" "small bank loan;" "slow, inefficient, positive;" "time, not efficient, knowledgeable, positive" and one "easier than I thought." From this it may be concluded that banks loans are available in advanced sectors for proof of concept, however, the processes are lengthier in time and more complicated than innovators would prefer.

Figure 6.5 shows who respondents believe leads these advanced sector companies: in 74% (n=21) of cases, the founding innovator leads the company and in a quarter of cases a management team.

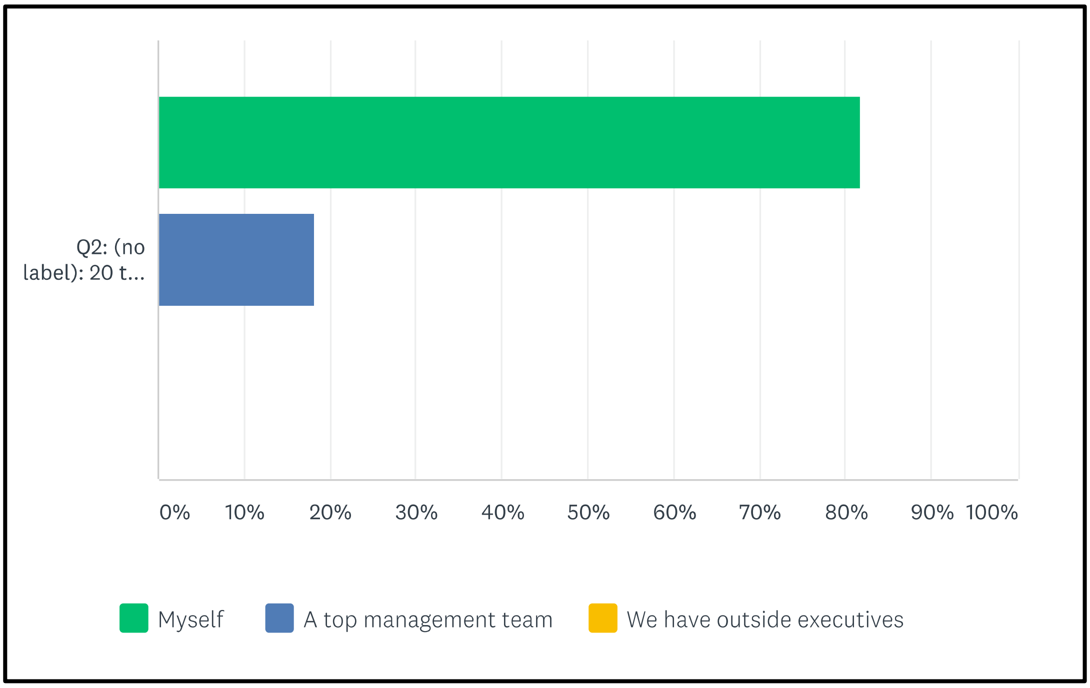


Figure 6.5: Who leads the company

To summaries, figure 6.6 gathers evidence from this section relating to the presence of factors related to innovator/entrepreneur agency in the survey results.

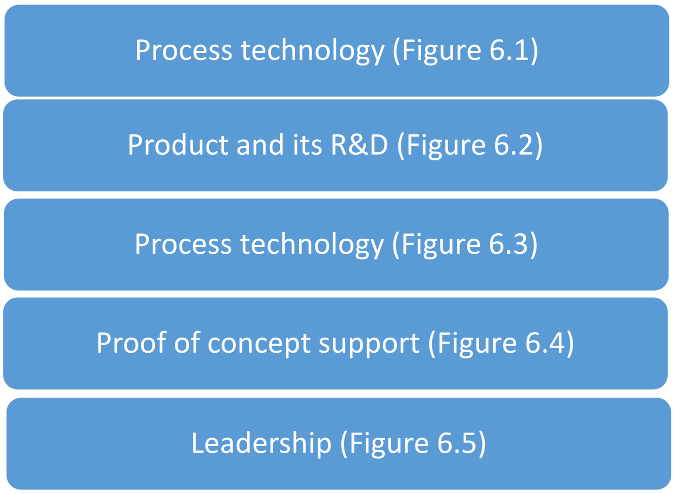


Figure 6.6: Summary of survey quantitative evidence relating to innovator/entrepreneur factors

6.2 Firm legitimacy

Annual sales of the companies are shown in figure 6.7 (in United Arab Emirates Dirham). shows 60% of companies with turnover below 2 million, with almost all (40%) trading above 8 million per year and one outlier trading above 20 million.

Under 10 million	59.26%
11 to 20 million	18.52%
21 to 30 million	18.52%
31 to 40 million	0.00%
41 to 100 million	3.70%
Above 100 million	0.00%

Figure 6.7: Previous year annual sales

Staff size cannot simply be taken as a proxy of successful growth, since firms may be over-staffed, especially where low cost (migrant) labour is available. Nonetheless, as figure 6.8 illustrates (Q-6) staff, including regular contractors, is over ten in half (52%, n=13) the companies, with the over half (48%) employing less than ten. Three companies employ over 31 staff.

< 10		48.15%
11 to 30		33.33%
31 to 50		11.11%
51 to 100	4/4	0.00%
100+	4/4	7.41%

Figure 6.8: Previous year annual sales

Figure-6.9 shows that half the companies (48%, n=12) received financial support in the form of a loan (from a bank or organisation such as the Khalifa Fund) to enable proof of concept.

Yes		48.15%
No	2/2	51.85%

Figure 6.9: Previous year annual sales

Figure 6.10 illustrates the market research conducted prior company launch (Q-13 data). One respondent answered, “own experience,” and one “online research.” Of the other

25 companies, only eight (29%) used a professional marketing consultant. The others (5 companies) conducted their own informal survey, with the largest set (12 companies, 45%) noticed a gap in the market and set about targeting it.

Used consultant		1/4	29.63%
Informal survey		2/4	18.52%
Notice market gap		4/4	44.44%
Other (please specify)	Responses	--	7.41%

Figure 6.10: Market research method prior to launch

Figure 6.11 illustrates the market entry routes taken by the companies (Q-14). 18% (5 companies) used an existing distributor and two companies made direct sales to customers.

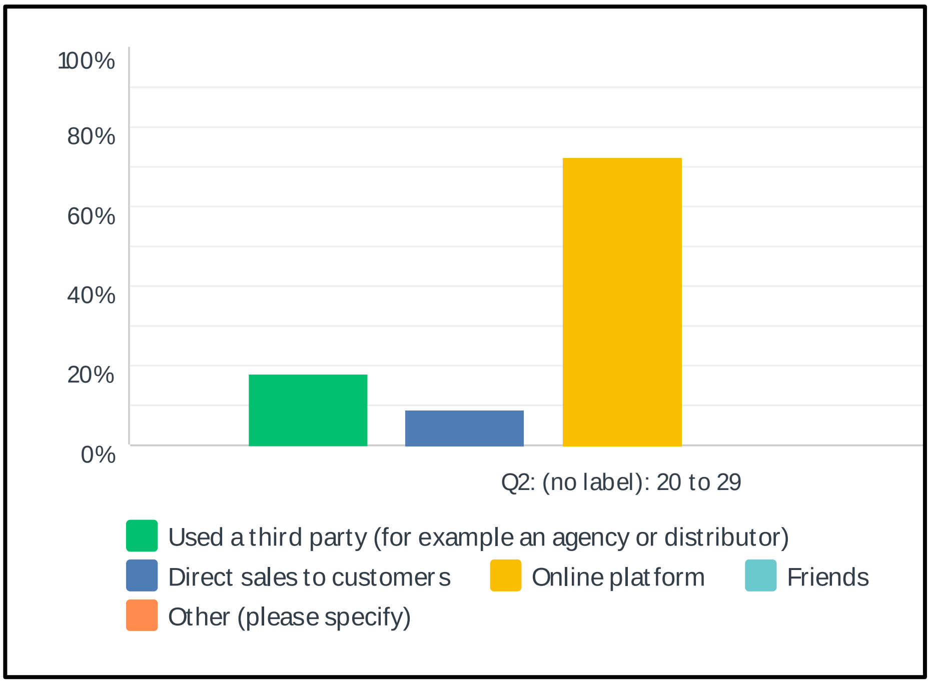


Figure 6.11: Market entry route

Twenty of the twenty-seven companies used an online platform to enter the market: often an inexpensive yet efficient and competitive entry route. Perhaps understandable given the high use of online platforms as a launch route, 72% (n=19) companies felt that publicity was important to their company growth as figure 6.12 (Q38) illustrates.

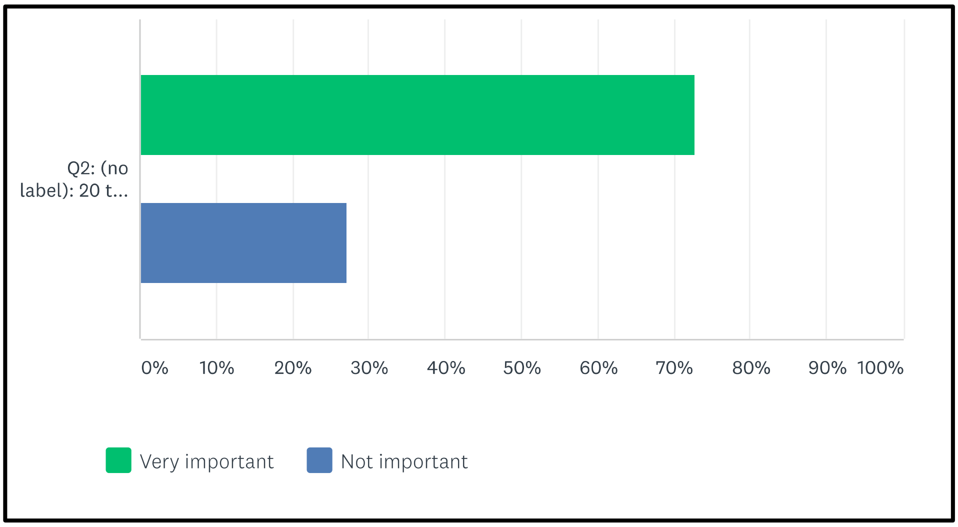


Figure 6.12: Market entry route

Legitimacy in the eyes of the consumer in part arises from listening and responding to customer feedback i.e. improving products to better solve customers' problems as shown in figure-6.13 (Q41) data.

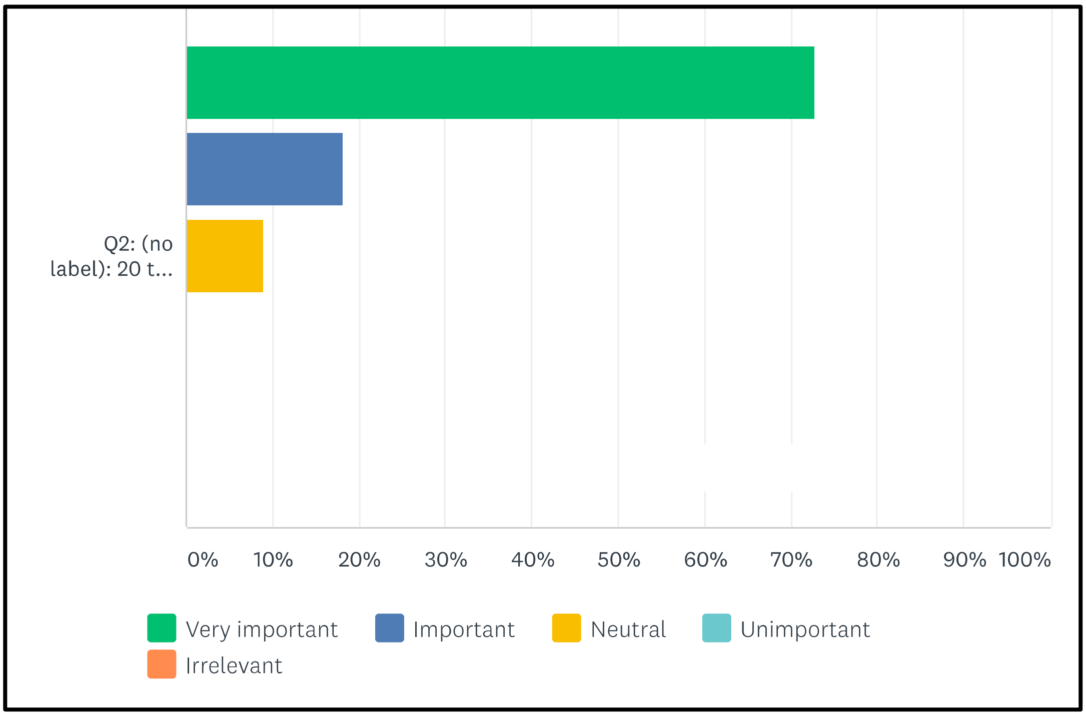


Figure 6.13: Important of listening to voice of customer as source of innovation ideas

Twenty-five respondents offered words describing *when you felt you were a successful businessperson* (Q-42). Out of these, the most common were customer feedback or recommendations, product applauded, profits and the ability to make supply agreements. Success then is interpreted by these respondents in terms of acceptance by customers and suppliers and the making of a profit. A series of questions asked the innovators about international linkages. Figure 6.14 summarises the results.

Importance of complying with international standards (Q52)	60% say critically important 37% say important
Importance of complementarity with international products (Q53)	70% say critically important 19% say important
Having international sales or supply partners (Q54)	70% yes to international partners
	30% no

Figure 6.14: Importance of international linkages

Q55 asked *are you a member of international research and development network which you hope will help you create future innovation*? Joining such networks is particularly difficult for start-up companies unless they have a key knowledge contribution.

Yes, this is very important	1/3	55.56%
We would like to join such networks	2/3	25.93%
No, this is not important	3/3	18.52%

Figure 6.15: Membership of international R&D network

Five of the twenty-seven companies say international R&D networks are unimportant, these include localised e-commerce companies such as wedding planning, beauty tips and cosmetic sales (each using customised software). For the other twenty-two companies such networks are important, and 14 companies (55%) are already members of international R&D networks. Companies were asked to indicate what might be the investor’s exit route, a point that should be considered in all start-up business plans (Q21).

Fifteen companies (55% chose private sale, 15% (4 companies) choose floatation (i.e. initial public offering of equity); and 26% technology licensing. Two companies skipped this question.

	Firm legitimacy factors	Evidence on firm legitimacy
1	Online presence + tools	Figure-6.12 online platform use
4	Linkages to MoU agencies	Figure-6.11 market entry route
6	Business support staff	Figure-6.9 receiving start-up financial support
9	Market entry and growth	Figure-6.8 recruiting, retaining staff Figure-6.13 listening and innovating
15	Supply + logistics	Figure-6.14 international sales and supply partners
20	Reputational capital	Figure-6.7 successfully trading
28	Entrepreneurs' Legitimacy	In eyes of staff, customers, suppliers, banks etc entrepreneur is legitimate
27	Business networks, customer voice	Figure-6.10 identified viable market
32	Logistics infrastructure	Figure-6.14 taking advantage of supply infrastructure
38	Clear international standards	Figure-6.14 international standard compliance

Figure 6.16: Summary of quantitative evidence from company survey relating to factors influencing company legitimacy

To take stock, the evidence for factors constituting firm legitimacy is gathered together in figure 6.16.

6.3 Marshalling resources

Amongst the resources marshalled to establish and grow innovative companies, income from sales (Q-6) as a resource for working capital and perhaps investment should not be underestimated. This is especially so working capital increases with recruitment and salary costs (Q-7) in order to strengthen the assemblage of talent. Other important marshalled resources include non-financial items such as help in start-up (Q-9), which is this case 78% of respondents highlight as significant and often includes both mentoring and loan for proof of concept (Q-10), benefiting half of these respondents. Proving idea works funding (Q-11), see figure 6.17, illustrates that 70% (19 companies) generated proof of concept capital either from savings or family and friends.

Own funds	1/4	33.33%
Family and friends	2/4	37.04%
Bank facility	3/4	14.81%
Loan from entrepreneurship fund	4/4	11.11%

Figure 6.17: Help received during start-up phase

Asked, "*What proportion of your total product (physical and service) do you yourself, as opposed to buy-in"*, respondents choose the options shown in figure 6.18 (Q-16). Approximately half the companies make over 41% of their product, with the other half buying in up to 40% of product. Of course, it cannot be assumed that one choice is superior to the other, especially since many of the product offers feature value-adding service content and purchasing artefacts that are more expensive to make is often the rational choice.

The source of start-up capital (Q-18) reported is savings 11 companies and family and friends 9 companies, making 20 companies generating start-up capital internally. Of the other seven companies, five received loans and two equity injection. Unfortunately, the questionnaire design did not allow respondents to choose more than one option, which may distort the picture.

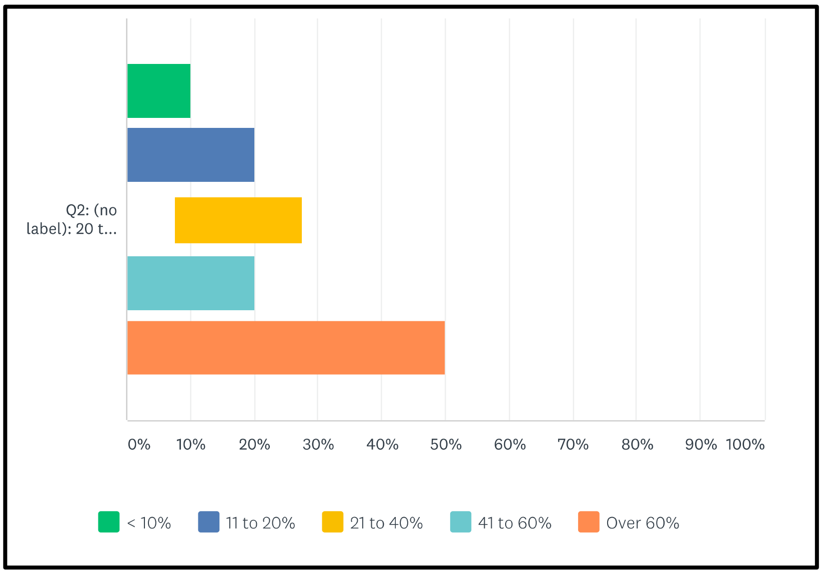


Figure 6.18: Proportion of product made or bought in

For example, it could be that an innovator used a combination of savings, family, and loan. Answers suggest that at start-up stage little external equity is available to advanced sector start-ups in UAE, since only two companies listed this. When asked to indicate the ownership of the companies (Q-19), identifying types of owners rather than proportion owned, as figure 6.19 illustrates.

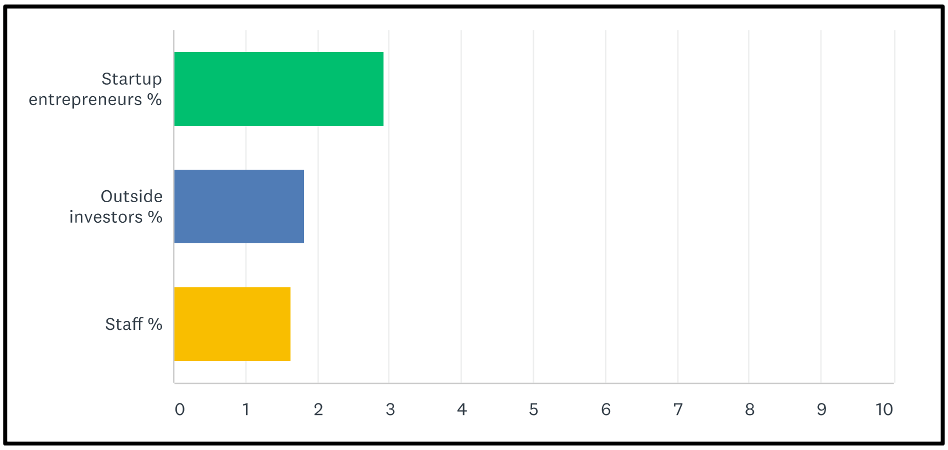


Figure 6.19: Current owners of company capital

One respondent failed to answer question-19; of the others 26 indicated entrepreneurial equity i.e. all of them with 12 also having external investors and 8 staff equity sharing. A deeper inquiry into financial structures would be necessary to conclude more, except to say that around half of advanced sector firms are attracting external investment meaning their growth is not limited by personal or family capital and also that equity injections are often accompanied by advice and introductions to business networks.

Figure 6.20 records company sales outside of the UAE (Q-20). Especially based in a small market, international sales are essential for SME growth. Often in VC circles a figure of 50% by the end of year-2 is used as a standard. The figures show that only 9% of the companies have reached this figure, ten companies still sell under 10% abroad.

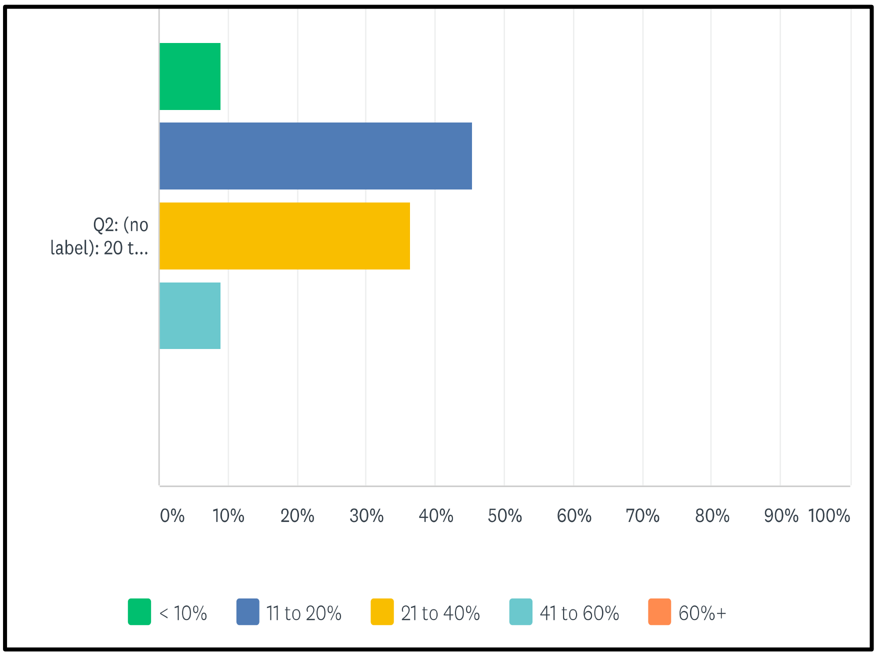


Figure 6.20: International sales levels

Often for start-up companies, *cash is king*. Since cashflow issues can jeopardise viability cost-control can be important and figure 6.21 shows that most companies are aware of this.

A great deal	40.74%
A lot	22.22%
A moderate amount	22.22%
A little	14.81%

Figure 6.21: Cost sensitivity

Once resources are marshalled companies begin trading the innovator/entrepreneur knows that an important milestone is reached when cash from sales reduces equity-burn. This is reflected in answer to Q-33: *Who's opinion of your firm made you feel you had a 'proper' business*. 58% say customers and 27% report bank or finance providers. One company owner said "Father" offered the opinion. As with figure 6.19, each of the two-thirds reporting customers or bank can be interpreted as meaning positive cashflow.

Resource assembly is much wider than cash and equipment: without people no business can survive. Figure 6.22 (Q-34) captures the professionals that innovators say were most important during their start-up stage. While Accountants (19%), lawyers (15%) and others (9%) technical and financial advisor) are mentioned, designers at 63% (16 companies) is the majority choice reflecting the online, service and knowledge basis of advanced technology companies.

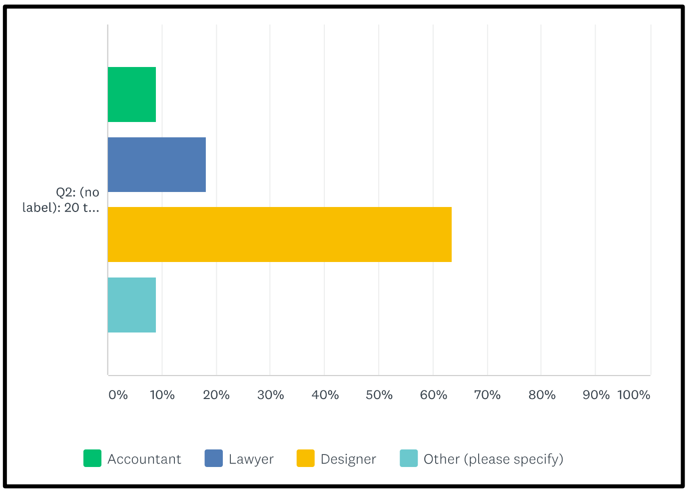


Figure 6.22: Professionals used during start-up phase

Only 11 respondents answered Q-35 on the degree to which shortage of professionals has limited growth since start-up. Nine of the 11 mentioned shortage of marketing professionals and two shortages of technical staff. This is an interesting response since lack of professionals can retard growth in developing economies; the answers suggest that overall, this is not the case in UAE. See figure 6.12 on importance of publicity.

Respondents were asked (Q-39) if a relationship with a large company has been important to their growth. No company felt relationships with a large company to be unimportant and 63% (17 companies) regarded their big-company relationship as very important.

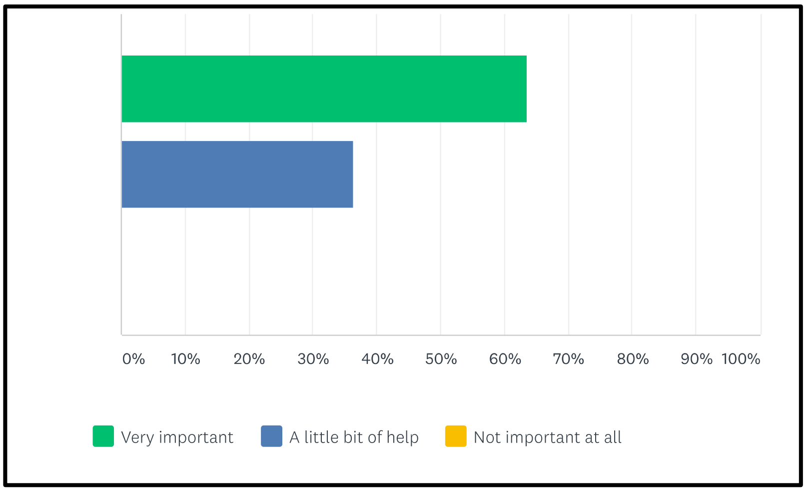


Figure 6.23: Importance of relationship with large company

Relationships are an important resource for SMEs to assemble, this is perhaps especially illustrated by relationships with large companies and online trading platforms.

Asked if the UAE tax system is help or hinderance (Q-46) the majority (55%) suggested it was neutral, see figure perhaps thinking of the 40% corporation tax rate on profits in other countries (UAE has a zero-% rate). Interestingly, despite this low tax rate, 18% (5-companies) felt it a hinderance.

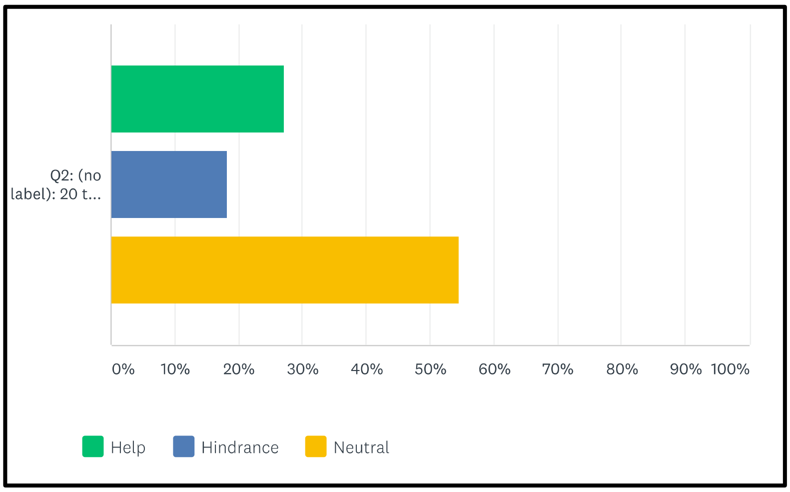


Figure 6.24: Attitudes towards UAE company taxes

Marshalling labour is an important aspect of resource marshalling. Answers to Q-49 (figure-6.25) reveal one company referring to a shortage of technical staff and others (55%, 14 companies) indicating that at times there are shortages, perhaps referring to shortage of marketing professionals (see figure 6.25). Overall, UAE labour markets (based on 'core' Emirati labour, a periphery of migrant labour including some specialist professionals) appears to deliver the needs of these companies.

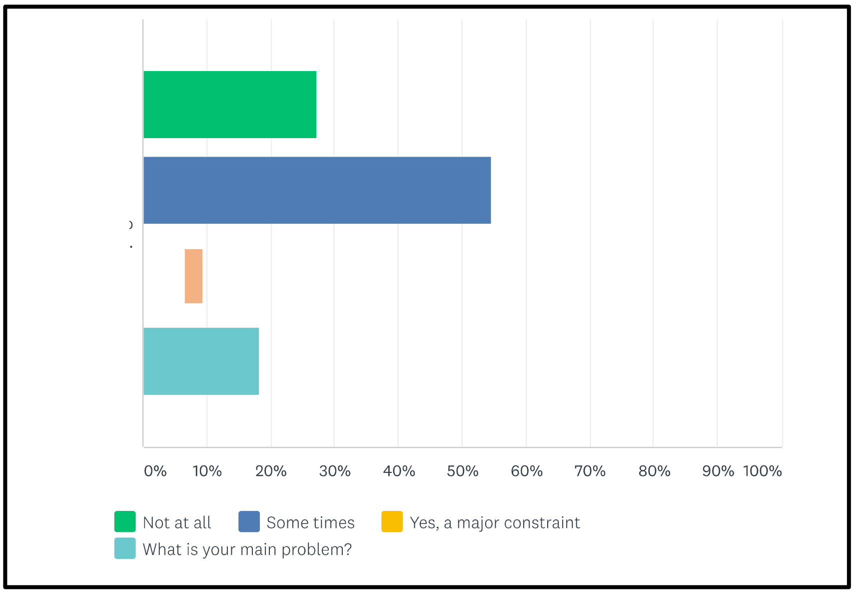


Figure 6.25: Labour shortages

Q-50 shows that 90% of these companies employ expert migrant labour, the same number (Q-51) also employing general migrant labour. It would appear that in use of migrant labour these advanced product companies do not differ from overall migrant labour employment patterns in UAE. Migrant labour then is a critical part of the resources marshalled by innovative product companies in UAE. As figure-6.20 revealed, 45% (11 companies) make over 21% of sales internationally, and (figure-6.11) twenty companies use an online platform for sales. These figures correspond closely with figure-26: 82% of companies (twenty companies) have an international sales or production partner.

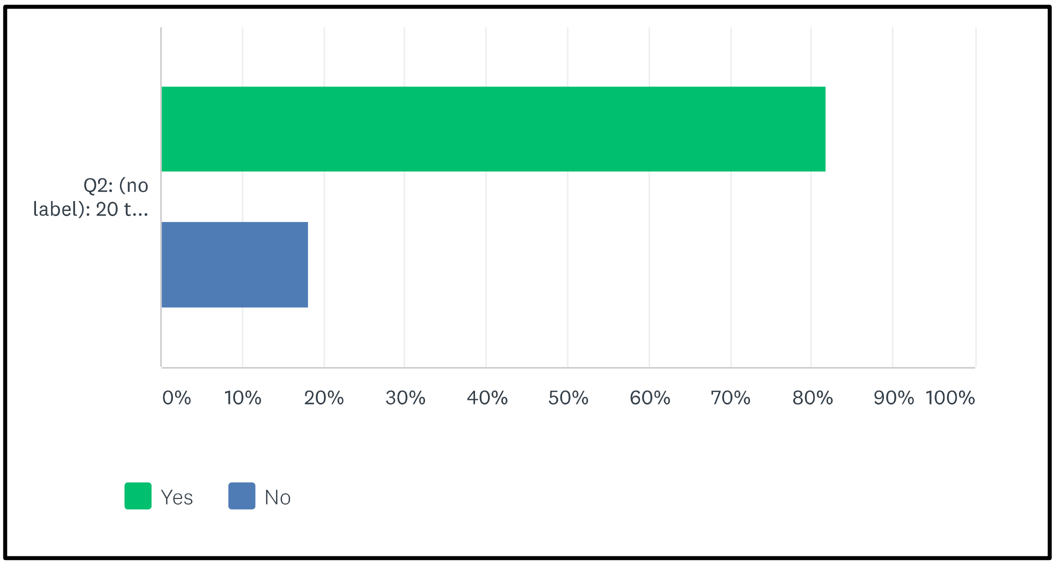


Figure 6.26: International sales of production partner

In some instances, these international partners may be an international sales platform or supplier: for long-term growth the quality of knowledge marshalled in these relationships is crucial. 64% of companies (18 companies) are members of international R&D networks, which they hope will support future innovation and a further three companies would like to join such a network.

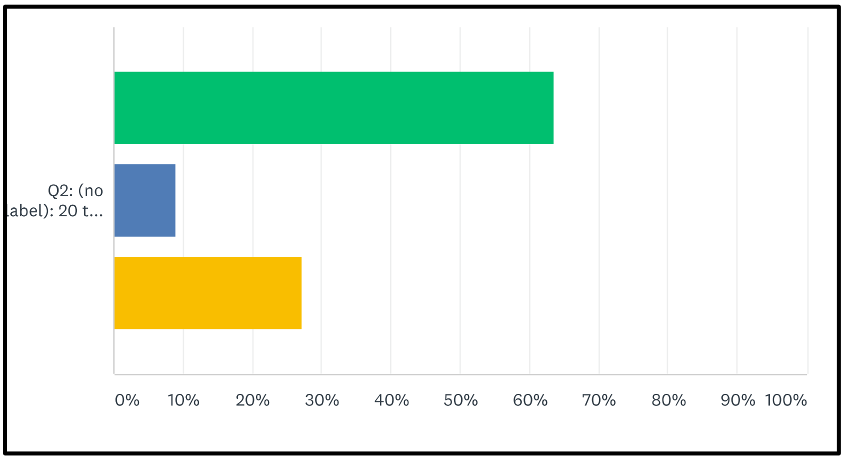


Figure 6.27: Membership of international R&D networks hopefully resulting in future innovation

Membership of international R&D networks is only of value if the company has the absorptive capacity to interpret the meaning of developments and the possible opportunities arising for the participating company. Answers to Q-56 reveal that three-quarters of companies (73%) believe they have the technical or scientific staff to understand and use knowledge in their sector. Evidence for factors showing the marshalling of resources by innovative UAE firms is gathered in figure 6.28.

	Marshalling resources factors	Evidence on resource marshalling
3	Fund and partners	Figure-6.19 financial structuring enabling company growth Figure-6.23 ability to establish and use relationships with large companies
12	Risk capital access/structures/exit	Figure-6.17 access to risk capital
13	Leverage, bank facilities	Figure-6.17 access to bank facilities
14	Costs and their control	Figure-6.18 make or buy decisions control costs Figure-6.21 high awareness of cost controls
17	Staff and partners	Figure-6.22 appropriate professionals available for start-ups
31	Regulations: IP, Tax	Figure-6.24 tax system not a hinderance Figure-6.27 ability to use IP in international R&D networks
36	Effective labour markets	Figure-6.25 ability to recruit labour includes migrants
37	Open expert migration	Figure-6.25 ability to recruit labour includes migrants
	International sales	Figure-6.20/figure-6.25 some yet limited international sales

Figure 6.28: Summary of quantitative evidence from company survey on marshalling resources

6.4 Knowledge flow activity

Evidence of the fourth set of factors embedded in framework 1 figure 3.1, taken from the literature review of innovation economics (Tables-3.3 and 3.4), was sought in the company survey: knowledge flow activity, a critical value-flow for companies entering and thriving in innovative sectors where exploitation of advanced knowledge is a qualifier condition.

Discussion above reveals that the surveyed companies from software (11 companies), seven life-science (8) and non-carbon companies (9) include a range of knowledge-intensive products (figure-6.2), the idea for which often came from visiting abroad or university study (figure-6.3). Ten companies responded to Q-17 asking for key words describing the main advanced technologies they use. Figure-29 shows that specific companies use knowledge related to specific products. More generally, 40% (9-

companies) have developed apps dedicated to their specific business. Use of digital technologies such as AI software diagnostics, database interrogation is generally in use.

Company-specific technologies	General purpose digital technologies general employed
Animal disease diagnostics	AI diagnostic algorithms
Medical devices	Online stock databases
Incineration	Apps
Solar technologies	
Hiperponic agriculture growing	
Smart meter	
Specialist batteries	
Smart tracking barcodes	

Figure 6.29: Summary of technologies used

In summary, company-specific knowledge and general advanced digital technology knowledge is employed by these Emirati innovative companies. Figure-6.14 notes that use of these technologies necessarily means compliance with international standards, complementarity with internationally accepted digital platforms and protocols (mobiles, operating systems etc).

Figure 6.30 reveals that no single company believes that its current knowledge base adequately addresses future needs. 73% (20 companies) have a specific knowledge base of future innovations, with other companies having less specifically “one or two ideas.”

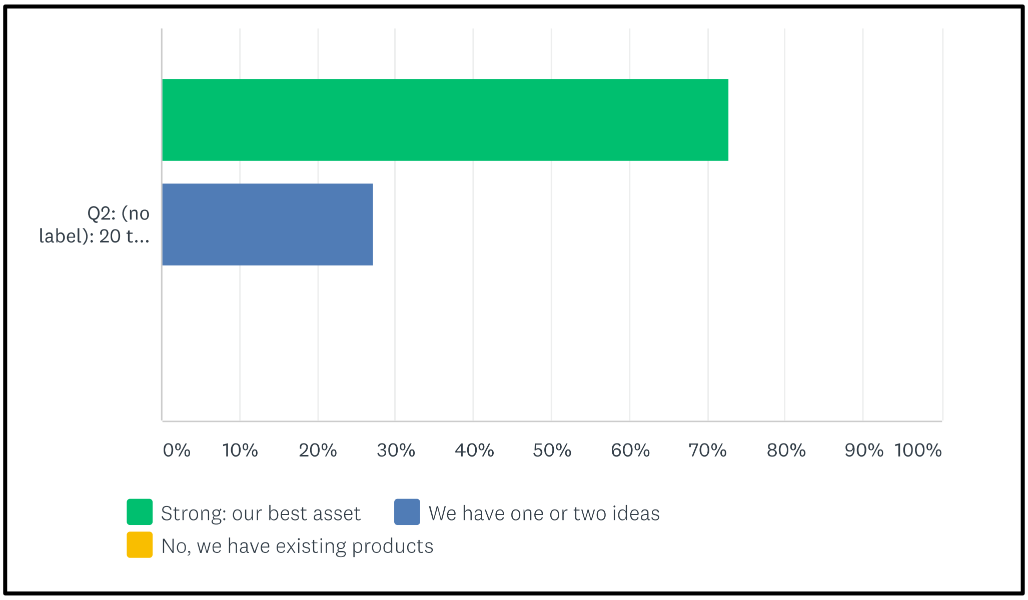


Figure 6.30: Innovation pipeline

Continuous knowledge flows are then critical to companies expecting to continually innovate either radically new products or to incrementally innovate improvements to existing products. What then are the knowledge-flow sources supporting innovative new product ideas for these advance technology companies?

Every single company benefited from some form of mentoring during start-up (Q-36) undoubtedly including both general business and tacit knowledge, to highly specific and formal codified knowledge. Figure 6.31 showing the source of the last 'big idea' for product development in these companies shows the importance of networking (proxied as conference): 45% of companies (11 companies) trace their last big idea to this source. This may overlap with the 'yourself' category since the individual innovators leading the company may have been the networking event attendee.

Other sources of ideas are other companies and media. Most notably, however, is the absence of development ideas from universities: no single company is getting ideas for innovative products from association with either Emirati or external universities. This suggests an important lack of connection not only to basic research but also to whatever applied research is being conducted in partner universities.

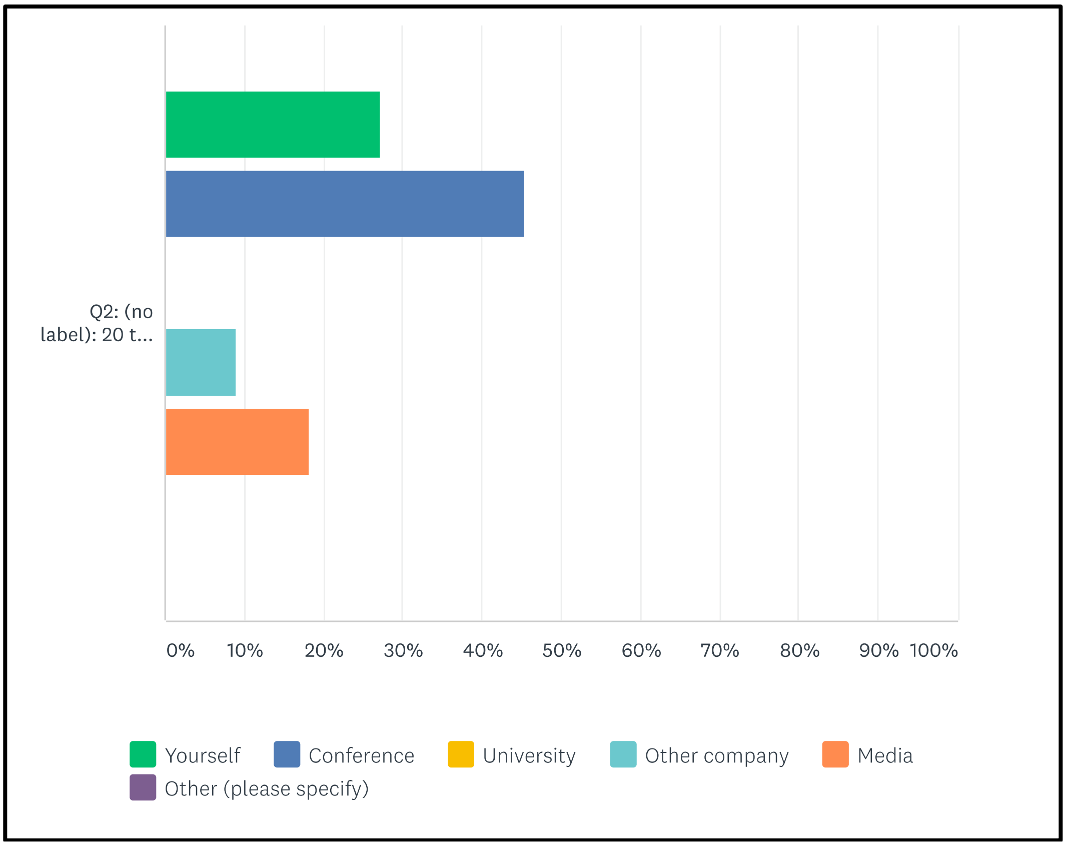


Figure 6.31: Source of last 'big idea' for product development

This is an important finding. Emirati membership of international knowledge networks is likely in the long-term to depend on their being able to contribute knowledge into the network – this finding suggests their contributions may be limited to knowledge developments within existing product paradigms. Additionally, the Emirati Government (*Vision 2030*) is spending considerable resources on university-based research in these advanced target sector. The findings in figure-6.30 suggest that this expenditure is bringing limited impact to companies in the advanced sectors. Discussion in later chapters will return to these important issues.

If not from universities, what then are the source of knowledge flows relevant to innovation by these advance technology companies? Figures 6.32 and 6.33 indicate the company's perception of knowledge flows for innovative ideas from suppliers and customers: frequently the source of ideas, though often (not always) incremental innovations.

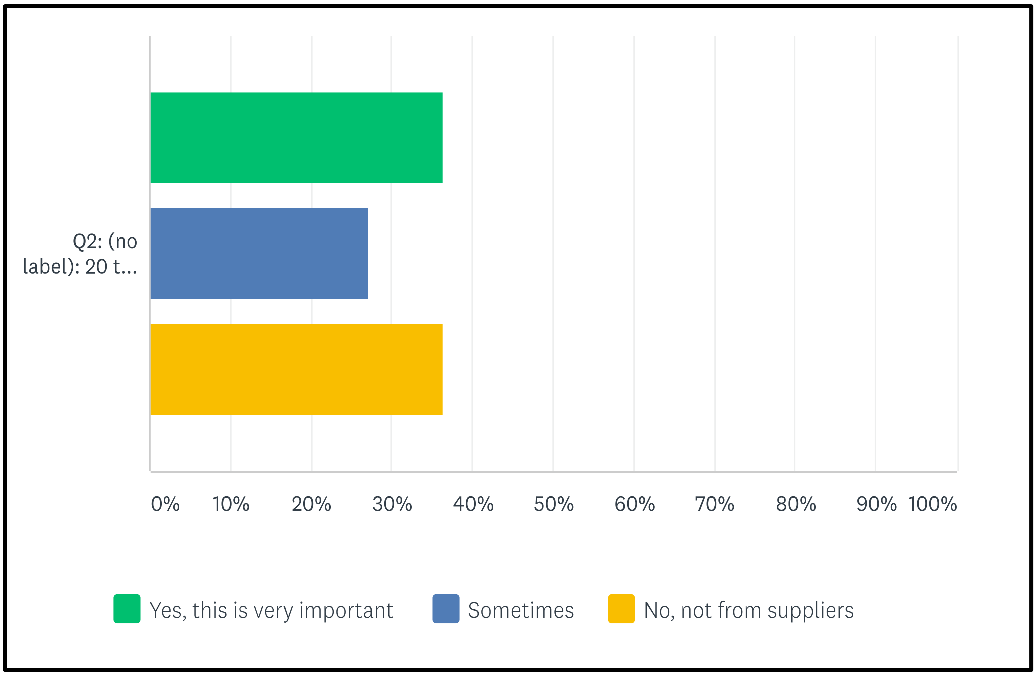


Figure 6.32: Knowledge flows for product innovation from suppliers

For one-third of companies (nine) suppliers are not a source of knowledge; for thirds suppliers are either very important (10 companies) or sometimes important (8 companies). These sources of knowledge flows are notably more significant than those from universities.

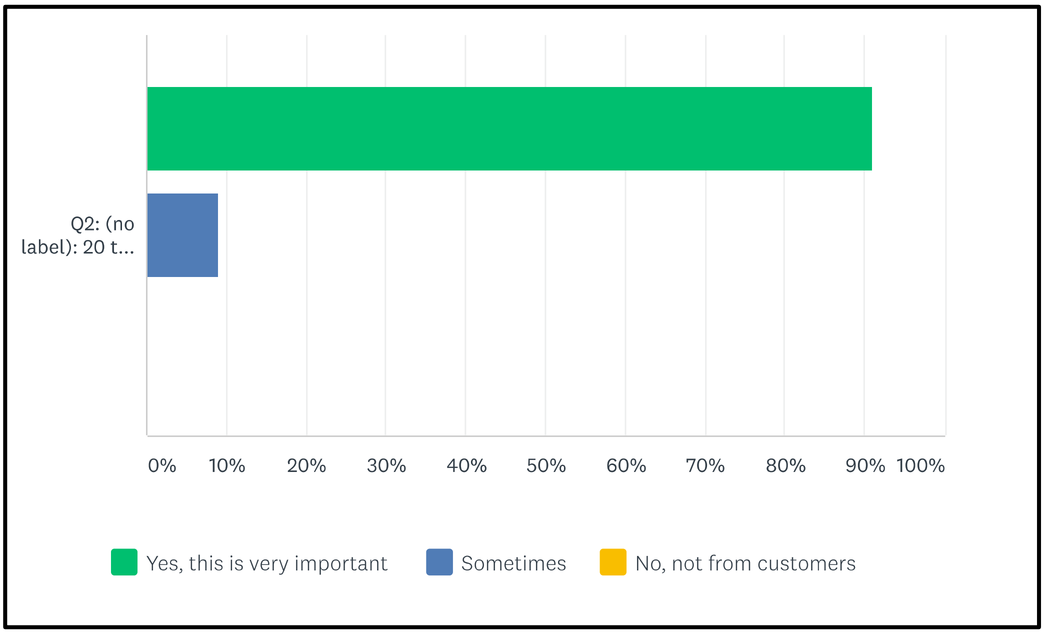


Figure 6.33: Knowledge flows for product innovation from customers

Customer-focus is perhaps a defining characteristic of competitive companies, though not always a defence against disruption. Figure-6.33 shows that all companies get some knowledge feedback from customers, only ‘sometimes’ for five companies only, while ‘very important’ for 82%. For this research the question posed is whether focus on customers limits product innovations to incremental change or whether incremental change is accompanying knowledge flows supporting potential radical product development?

Seventeen of the surveyed companies as might be expected in a context such as UAE that encourages higher education, employ people with higher or doctoral qualifications as figure-6.34 illustrates and is expected from the figure-6.26 data that the companies have the absorptive capacity to operate in international knowledge networks.

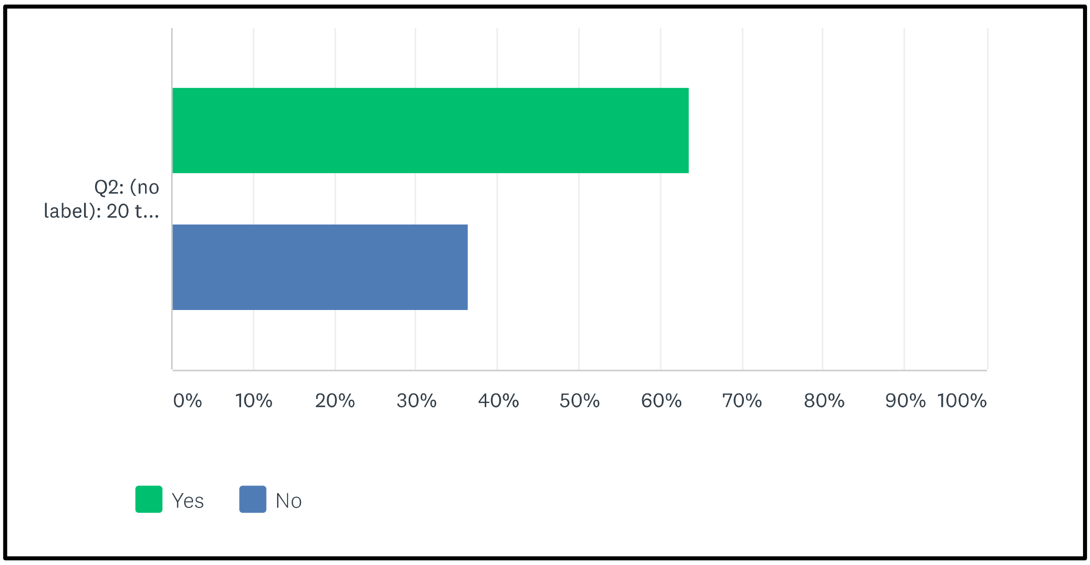


Figure 6.34: Company employment of higher/PhD qualified staff

This employment pattern demonstrates not only the capability of operating in international knowledge networks, but it also suggests that lack of engagement with Emirati universities as a knowledge flow source for new products is not because the companies lack adequate absorptive capacity.

Only 7 respondents answered Q-30 asking, “*If you are linked to university or other networks of innovation in UAE, can you give a short example of practical ideas you’ve gained from the network? You answer might be about technology, contacts, a business* *model or market opportunities".* Upon reflection the question may have been better broken down into component parts. One respondent simply answered 'no.' The other six comments are shown below.

- *I attend sector conferences in the US*
- *Updated analytics data sources*
- *Energy gap group*
- *Improved programming*
- *University hospital*
- *Masder innovation centre Solar technology*

There is a clear disjuncture between the figure 6.31 data showing no knowledge flows from universities and these six respondents commenting under Q-30. Perhaps the point is that though these six connect with universities (some Emirati others international) no product development ideas flow from these connections? Most importantly, 21 companies had no links with universities at all to report a point to which the analysis chapter below will return.

The picture emerging is that important knowledge flows for these companies come from start-up mentors (Q-40), customers (Q-41/25) and suppliers (Q-26), which include large company relationships (Q-39) and business professionals employed (Q-34). Only four companies (Q-32) spend more than 6% of salary budget on training (one of these over 11%): training then is not a source of new product knowledge flows for most of these companies.

When asked to rank professional staff skills in order of importance to the future of the company, with eleven companies fully completing the question, of the choices (technical, marketing, sales, and finance, eight companies ranked technical skills as most important, followed by marketing (2 companies), sales (1 company) and no company ranked finance as most important. This ranking is perhaps typical for early-stage technology companies, illustrating that technical knowledge is paramount in creating and improving products. Two-thirds of companies (Q-37) say that technical networks are their main source of knowledge flow for new products, with one-third saying their large company relationships provide innovation knowledge flow. No single company identified universities as their most important knowledge flow.

To summarise, figure-6.35 indicates evidence from the company survey relevant to selected factors (from the table-3.4 summary) influencing company innovation. Perhaps most importantly the data reveals significant absorptive capacity within the companies and an absence of university-industry links.

6.5 UAE institutions

Moving to a wider 'F-stop,' this section explores evidence from the survey on the suitability of existing institutional arrangements in UAE to encourage and support innovative companies. After an overview, evidence of institutional support is summarised and comments relating to the principal economic development agency, the Khalifa Fund, are presented.

	Knowledge flow factors	Evidence of knowledge flows
2	Links to UILs/SSIs/Firms	Figures31/32: ideas from suppliers and customers
7	Links to firms and mentors	Figure-6.31 wide use of business mentors in start-up, less so afterwards
18	Useful knowledge flows	Figure-6.34 flows of knowledge but not from universities
19	Education standards/ staff training	Q-32 small spend on training; Figure-6.34 recruit highly educated staff
21	Business professionals	Q-34 ability to recruit and rank professionals
22	Business mentors	Figure-6.31 wide use of business mentors in start-up, less so afterwards
23	UILs, company R&D links	Figure-6.30 all communications have innovation pipeline
24	Media representation	Figure-6.31 companies gain ideas for media
25	Big company learning	Figure-6.23 flow of knowledge from large company partners
30	ICT infrastructure	Figure-6.29 use of advanced and general-purpose ICTs
33	Rule of law/no corruption	Q-45 IP law adhered to; Q-47 no reports of any corruption
35	Exit market	Q-21 preference for private sale exit; no UAE formal market
40	Complementarities	Figure-6.14 compliance with standards, seeking complementarities
42	Involved in R&D networks	Figure-6.15 most involved in international R&D networks, benefits unclear
43	Staff with absorptive capacity	igure-6.34 employment of MSc/PhD staff

Figure 6.35: Summary of quantitative evidence from company survey on knowledge flows

Bearing in mind the difficulty of the challenge to join the small group of sustainable high-income countries, it is noteworthy that 100% of these twenty-seven companies express the self-confidence that UAE will its vision by the year 2030 (Q-64). Only two companies suggested improvements to the innovation ecosystem (bank loans at lower interest and improved links to international companies), none mentioned university-industry links (Q-62). Only one company made suggestions for improving innovation in their sector: one suggesting university training on setting up companies (Q-63). All companies when asked if they had experienced corruption (11 companies answering) said no. It seems fair to conclude that the point of view of these companies is that the innovation ecosystem in UAE is satisfactorily supporting innovation.

Data above lends qualified support to this conclusion. Start-up capital seems readily available (Q-18) including for proof of concept and further rounds to support growth (Q-19; 22). Exit routes by private sale (Q-21) are aspirational, however, no company pointed to a formal early-stage private equity market. Two-thirds of companies are able to innovate in advanced sectors (Q-5), enjoying significant levels of sales growth (Q-6), though without levels of international sales necessary for sustainability. Qualified staff (Q-31) and professional services (Q-34) are available in a business-friendly context (Q-48), operating with clear IP law (Q-45) and tax regime (Q-46). Labour shortages appear minimal (Q-49), with expert and general migrant labour also available (Q-50; 51). The companies appear connected into international R&D networks (Q-55) though the degree of knowledge flows from and into these networks may be limited by negligible university linkages (Q-30). When asked to identify barrier to growth (Q-43), companies eleven companies responded and mentioned the following.

1. *Financial trading Regulations*
2. *Software engineers*
3. *Young people credit card ownership*
4. *Sales tax*
5. *Fear of failure*
6. *International sales/payments*

While important, items (1) to (4) seem to require policy adjustment that is within the existing institutional framework. Item (5) is a subjective barrier, which may be present in institutional arrangements everywhere, connecting with the Q-63 suggestion of more entrepreneurship education in universities. None of the companies answered Q-43 mentioned knowledge flows with universities.

Existing institutional arrangements for innovation in UAE appear satisfactory to Emirati innovators. This conclusion will be discussed in the following analysis chapters, including the important omission of knowledge flows between companies and universities and its implications for radical product innovation and contributions to international knowledge networks.

As the principal economic development agency providing policy guidance, funding support, mentoring and incubation, the Khalifa Fund plays a pivotal role in UAE's innovation ecosystem. A series of questions in the survey investigated company relationships with the KF. 90% of companies said they were aware of the KF (Q-57). Only 50% of the companies have accessed the KF business development toolkit (Q-58), perhaps disappointing given the large investment in its provision, with only 50% of these (i.e. 25% of all companies) finding the toolkit useful (Q-59). 71% of companies found the KF useful, with only four companies finding its services and support 'poor' (Q-59). Of the eight companies replying to Q-60 on the nature of help received from the KF, four mentioned helps from business development staff and two helps with linking to other firms; only one company mentioned help raising capital. It appears that almost all companies know of the KF, its toolkit is of value only to a minority of firms and that its most useful service, from the viewpoint of innovative firms, are its business development services.

Overall, then the institutional arrangements are supporting innovative companies in UAE; subsequent chapters will consider how sustainable this is.

6.6 Interactivity in complex ecosystem

From the point-of-view of these innovative firms, what is the extend and quality of interactivity between agents in the UAE's innovation ecosystem? Are agents in the ecosystem responding to events/decisions of other agents in ways that encourage and support innovation?

The list of responses from companies in section 6.5 suggests that with the major exception of university-industry linkages and relatively small international sales, the current state of the ecosystem is healthy, however, its future as sustaining high-income based on innovative products is questioned by what appears to be low levels of interactivity likely to create radically new innovations from basic or applied research, which even if arising from knowledge networks or internal R&D benefits from cutting edge university research. It may also be disappointing to the KF that only 25% of innovative companies make significant use of its services.

Clearly there is a great deal of interactivity with UAE’s innovation ecosystem benefiting innovative companies. Three-quarters of the companies are under three years of age i.e. have survived the first year of trading suggesting that arrangements for start-up by innovative companies are positive. These include mentoring, start-up capital, legal arrangements, IP protection and support for market entry for companies deploying advance technologies. Relative low rates of international sales (Q-20) especially from such a small economy may be concerning. Positive interactions between companies and their suppliers and customers also suggests the ecosystem is providing positive feedback loops, which the companies have the absorptive capacity to exploit.

Similarly, relationships with large companies (especially platform companies, Q-39) and attendance at international conferences (Q-37) are evidence of an ecosystem benefiting from knowledge flow stimuli including the ability to comply with international standards and complementarities (Q-52/52). These feedback loops suggest a potential for increased international sales, provided the products are novel and competitive.

Overall acceptance of the Government’s *2030 Vision* and 100% self-confidence that it can be achieved (Q-65) suggest positive interaction between Government and innovative companies.

In summary, interactivity in UAE’s innovation ecosystem has helped build innovative companies in advanced technology sectors; in. this case software, life-science, and non-carbon technologies. Questions remain about the ability of the ecosystem over time, i.e. the next twelve years until 2030, to sustainably create innovation. This qualification is especially so considering low interactivity between companies and universities. Of course, the leaders of today’s innovative companies are focused on today.

6.7 Meta-economic trends and UAE’s changing technological ecosystem

From the viewpoint of creating a high-income economy based sustainably on innovation in emergent sectors, the most important finding of this survey is that UAE is successfully launching companies with viable products (trading more than one year), a pipeline of innovations (figure 6.30), membership of international knowledge networks (figure

6.27) and (although at a low level) international sales. Put optimistically, UAE's innovation ecosystem is successfully creating viable companies who assess themselves as having a sustainable pipeline of innovations in emergent sectors. Notable deficiencies in the ecosystem such as (a) university-industry commercialisation links and (b) levels of international sales and amongst the challenges the ecosystem needs to strengthen to become sustainable.

6.8 Meta-economic governances in UAE's changing technological ecosystem

It is said that countries obtain sovereignty in order to give it away; the meaning of which is that have only recently achieved independence and unity (1971) UAE has since subscribed to regional governances obliging compliance with trade and quality standards. In UAE's case important aspects of global governances supporting its innovation ecosystem diversifying from oil-dependence into advanced sectors including membership of international knowledge networks; acceptance of global product standards and financial instruments; use of international migrant expert and general labour. UAE has acceded to over one hundred multilateral and bilateral agreements impacting on trade and its conduct in international markets, embracing global governances for ICTs and other advanced technologies.

Conclusion

There is little research on knowledge-intensive innovative sectors in UAE, in part because of the difficulties gathering data. Although a quantitative dataset of twenty-seven companies is relatively small, in a context where privacy from strangers is strong, the dataset represents an important contribution to research on UAE innovation.

1.1.5. Principal conclusions

Four important conclusions arise from analysis of this quantitative data. Firstly, there is evidence for almost all the 43 factors identified in table-3.4 as characterising an environment of sustainable innovation in emerging technological sectors: in this case software, non-carbon, and life-science. This evidence is summarised in Table 6.1, which is a compilation of the conclusions reached in the first four sections of this chapter. Specifically, the dataset includes responses to (most of) 65 questions by eleven software companies, seven life-science and nine non-carbons, designed to test for the presence of the 43 factors. Evidence summarised in Table 6.1 suggests that in almost all cases these factors can be found in UAE's companies; international sales and university-linkages being weaker points. It therefore seems fair to conclude that though UAE is a developing economy, it already has many of the characteristics of a developed ecosystem for innovation. Discussion in the following chapters will consider the extent to which UAE as an already high-income economy (oil resources) differentiates it from other developing economies.

Section 6.6 suggests that the UAE has a successful ecosystem for innovation in advanced sectors. Internal and external stimuli are resulting in interpretations and actions by agents (both individual innovators and organisations) sustaining innovation. How sustainable over time and how successful in advanced sectors this innovation is likely to be will feature prominently in later discussions.

A third conclusion is that for a small sized economy, the innovation ecosystem is not resulting in export-led growth or innovation. As figures-6.20 and 6.26 reveal international sales for most of the innovative companies are somewhat limited.

The survey therefore reveals that in the innovation ecosystem a major retardant factor appears to be the number of international sales, noting that there is a close correlation (at 0.68) between the UAE innovative companies enjoying linkages with large companies and amounts of sales abroad.

A fourth conclusion is that commercialisation of R&D from UAE universities is not playing a major part in the success of innovative companies. Like developed economies everywhere, knowledge flows universities receiving substantial Government investment for applied research and incubation are having little impact on innovative companies. The survey shows that companies receiving Khalifa Fund help during incubation are more likely to have university links, in many cases the universities to which the innovative companies are linked are foreign universities.

	43 factors	Evidence
2	Links to UILs/SSIs/Firms	Figures31/32: ideas from suppliers and customers
3	Fund and partners	Figure-6.19 financial structuring enabling company growth Figure-6.23 ability to establish and use relationships with large companies
4	Linkages to MoU agencies	Figure-6.11 market entry route
5	Business led incubation facilities	Figure-6.3 incubators amongst source of ideas for innovations
6	Business support staff	Figure-6.9 receiving start-up financial support
7	Links to firms and mentors	Figure-6.31 wide use of business mentors in start-up, less so afterwards
8	Proof of concept support	Figure-6.4 and 6.17
9	Market entry and growth	Figure-6.8 recruiting, retaining staff Figure-6.13 listening and innovating
10	Product and its R&D	Figure-6.2 company products
11	Process technology	Figure-6.1 innovative companies surviving start-up stage
12	Risk capital access/structures/exit	Figure-6.17 access to risk capital
13	Leverage, bank facilities	Figure-6.17 access to bank facilities
14	Costs and their control	Figure-6.18 make or buy decisions control costs Figure-6.21 high awareness of cost controls
15	Supply + logistics	Figure-6.14 international sales and supply partners
16	Leadership	Figure-6.5 innovator entrepreneurship
17	Staff and partners	Figure-6.22 appropriate professionals available for start-ups
18	Useful knowledge flows	Figure-6.34 flows of knowledge but not from universities
19	Education standards/ staff training	Q-32 small spend on training; Figure-6.34 recruit highly educated staff
20	Reputational capital	Figure-6.7 successfully trading
21	Business professionals	Q-34 ability to recruit and rank professionals
22	Business mentors	Figure-6.31 wide use of business mentors in start-up, less so afterwards
23	UILs, company R&D links	Figure-6.30 all companies have innovation pipeline
24	Media representation	Figure-6.31 companies gain ideas for media
25	Big company learning	Figure-6.23 flow of knowledge from large company partners
26	Business mentors	Figure-6.31
27	Business networks, customer voice	Figure-6.10 identified viable market
28	Entrepreneurs’ Legitimacy	In eyes of staff, customers, suppliers, banks etc entrepreneur is legitimate
29	Business professionals	Q-34
30	ICT infrastructure	Figure-6.29 use of advanced and general-purpose ICTs
31	Regulations: IP, Tax	Figure-6.24 tax system not a hinderance Figure-6.27 ability to use IP in international R&D networks
32	Logistics infrastructure	Figure-6.14 taking advantage of supply infrastructure
33	Rule of law/no corruption	Q-45 IP law adhered to; Q-47 no reports of any corruption
34	Policies: grants, business friendly	Figure-6.17
35	Exit market	Q-21 preference for private sale exit; no UAE formal market
36	Effective labour markets	Figure-6.25 ability to recruit labour includes migrants
37	Open expert migration	Figure-6.25 ability to recruit labour includes migrants
38	Clear international standards	Figure-6.14 international standard compliance
39	Routes to connectivity	Figure-6.14
40	Complementarities	Figure-6.14 compliance with standards, seeking complementarities
41	Inward FDI learning opportunities	Figure-6.14;
42	Involved in R&D networks	Figure-6.15 most involved in international R&D networks, benefits unclear
43	Staff with absorptive capacity	Figure-6.34 employment of MSc/PhD staff

Figure 6.36: Summary of quantitative evidence relating to 43 factors relevant to UAE sustainable innovation found in survey of companies

These four conclusions each have major theoretical and policy implications, to which later chapters will return. Chapter-7 which follows, considers the extent to which the results of the survey correspond with the results of interviews with UAE company innovators.

Correlations

Though care must be taking in deducing correlations from small samples, in four areas the dataset suggests clear conclusions on innovator gender and sectors: the importance of linkages with large companies, the significance of help from the Khalifa Fund during incubation for later success and the issue of university linkages.

- No correlation is apparent (0.12) between gender and sector. There is a strong correlation between company age and sector at 0.49 with software companies tending to be younger and non-carbon companies older.

- Companies enjoying high levels of international sales, at a strong correlation of 0.68 also enjoy the highest growth rate of sales, suggesting that those companies limiting efforts to domestic markets are choosing to limit their upside. At 0.48 unsurprisingly strong links to large companies correlate with higher sales and staff numbers grow with sales at a 0.48 correlation. UAE companies in software tend to most have links with large companies (0.43 correlation).

- One of the strongest correlations at 0.65 is having help from the KF and using close links with a university, though there is little correlation between KF help and sales growth (0.14), sector (0.35) or amount of international sales (0.36). Life-science companies are headed by older innovators, with non-carbon having the youngest – a correlation of (0.49). There is only a weak correlation (0.17) between university networking and international sales.

- Those companies with university links are not price sensitive (0.15 correlation). University links at 0.37 only weakly correlate with sector, international R&D links are slightly more correlated to sector at 0.42. The principal correlate to strong university links is having had help from the Khalifa Fund during start-up at 0.65.

In summary, the chapter has presented quantitative data from a survey of twenty-one officials, incubation manager and KF leaders and in doing so now able to integrate this quantitative data with the conclusions of qualitative from the previous chapter. This integration of qualitative and quantitative data is shown in table-6.37, structured by the 43-factors constituting the figure-3.2 research framework.

	Innovator/entrepreneur factors	Evidence
1	Online presence + tools	Figure-6.12 online platform use Online presence appears strong; may not be as strong in actual trading
2	Links to UILs/SSIs/Firms	Figures31/32: ideas from suppliers and customers R-17 incubators led by academics not business-persons R-2 only a few universities have business orientation + no international university
3	Fund and partners	Figure-6.19 financial structuring enabling company growth Figure-6.23 ability to establish and use relationships with large companies R-17 suggests incubation exit criteria too loose, not business-oriented
4	Linkages to MoU agencies	Figure-6.11 market entry route R-17 and others point to lack of applied R&D in UAE universities
5	Business led incubation facilities	Figure-6.3 incubators amongst source of ideas for innovations R-11 and R15 note incubates must have a business plan, route to market
6	Business support staff	Figure-6.9 receiving startup financial support
7	Links to firms and mentors	Figure-6.31 wide use of business mentors in startup, less so afterwards Links to large companies developed after launch, not before
8	Proof of concept support	Figure-6.4 R-3 and R-6 emphasise the ability of innovators to lead incubation processes
9	Market entry and growth	Figure-6.13 listening and innovating Figure-6.8 recruiting, retaining staff R-15 points to stiff competition in international product markets
10	Product and its R&D	Figure-6.2 company products R-15 and R-17 emphasise applied research and trawling for commercialisable research
11	Process technology	Figure-6.1 innovative companies surviving startup stage
12	Risk capital access/structures/exit	Figure-6.17 access to risk capital R-11 says many firms accessing publicly funded startup capital
13	Leverage, bank facilities	Figure-6.17 access to bank facilities R-2 notes the success of international companies in advanced sector inside R=4: UAE in competition with UAE companies: without profit projects it is difficult to raise private investment, except perhaps for proof of concept
14	Costs and their control	Figure-6.18 make or buy decisions control costs Figure-6.21 high awareness of cost controls R-3 and R-4 suggest products launched are insufficiently cost sensitive
15	Supply + logistics	Figure-6.14 international sales and supply partners
16	Leadership	Figure-6.5 innovator entrepreneurship R-10 and R-17 evidence success support innovators starting up companies

17	Staff and partners	Figure-6.22 appropriate professionals available for startups Fundamentally, university incubators are not led by businesspeople and often have little interaction with trading businesses
18	Useful knowledge flows	Figure-6.34 flows of knowledge but not from universities R-10 suggests UAE universities focused on formal knowledge to exclusion of tacit learning Limited impact of researchers brought from abroad
19	Education standards/ staff training	Q-32 small spend on training; Figure-6.34 recruit highly educated staff R-1 companies able to recruit MSc/PhD trained staff
20	Reputational capital	Figure-6.7 successfully trading R-1 points to UAE's success branding itself as centre for innovation R-11 and R-17's comments suggest UAE innovative firm reputations are confined to within UAE and not in international markets
21	Business professionals	Q-34 ability to recruit and rank professionals
22	Business mentors	Figure-6.31 wide use of business mentors in startup, less so afterwards Business mentors from public agencies not trading businesses
23	UILs, company R&D links	Figure-6.30 all communications have innovation pipeline R-17: links are limited or non-existent R-15 limited array of worthwhile projects (R-16 blames lack of funding)
24	Media representation	Figure-6.31 companies gain ideas for media R-17 media pictures state support, not private sector support, for innovation
25	Big company learning	Figure-6.23 flow of knowledge from large company partners R-16 suggests little learning large companies
26	Business mentors	Figure-6.31
27	Business networks, customer voice	Figure-6.10 identified viable market
28	Entrepreneurs' Legitimacy	In eyes of staff, customers, suppliers, banks etc entrepreneur legitimate R-17's point about little applied R&D in UAE universities may detract from Emirati innovators legitimacy in international R&D networks
29	Business professionals	Q-34
30	ICT infrastructure	Figure-6.29 use of advanced and general-purpose ICTs
31	Regulations: IP, Tax	Figure-6.24 tax system not a hinderance Figure-6.27 ability to use IP in international R&D networks R-16 and 17 say university incubators focus on intermediate goals such as patenting rather than outcome goal of successfully traded products R-1 seems to privilege basic research above applied research for UAE universities
32	Logistics infrastructure	Figure-6.14 taking advantage of supply infrastructure
33	Rule of law/no corruption	Q-45 IP law adhered to; Q-47 no reports of any corruption 100% agreed no corruption in advanced firms
34	Policies: grants, business friendly	Figure-6.17
35	Exit market	Q-21 preference for private sale exit; no UAE formal market R-6 says firms under-performing; no example yet of successful exit
36	Effective labour markets	Figure-6.25 ability to recruit labour includes migrants
37	Open expert migration	Figure-6.25 ability to recruit labour includes migrants
38	Clear international standards	Figure-6.14 international standard compliance
39	Routes to connectivity	Figure-6.14
40	Complementarities	Figure-6.14 compliance with standards, seeking complementarities

41	Inward FDI learning opportunities	Figure-6.14;
42	Involved in R&D networks	Figure-6.15 most involved in international R&D networks, benefits unclear R-16: without knowledge contribution, UAE firms may not hold places in key international R&D networks developing next generation products
43	Staff with absorptive capacity	Figure-6.34 employment of MSc/PhD staff R-16 foreign staff cannot be grant-holders or lead incubation

Figure 6.37: Summary of evidence qualitative and quantitative evidence relating to 43 factors relevant to UAE sustainable innovation

As noted in the Methods chapter, this is primarily qualitative research. This chapter has presented and commented upon quantitative from a survey of 27 innovative UAE companies distributed amongst the non-carbon, software, and life-science target sectors. As noted in the Methods chapter, while mixed in method, it is the qualitative methods that are the primary evidence base of this research. The evidence from the survey is designed to establish the presence and strength of the 43-factors identified from previous research on innovation, constituting the new framework developed in Chapter-3. The chapter has presented thirty-two graphs or charts detailed evidence relating to innovation activity by entrepreneurs in UAE and in doing so contributed to the rich picture of context and culture required to meet objective four of this research. The research turns now to triangulating this quantitative data and the qualitative data from the previous chapter with previous research literature and in doing so to answer the research question, formulate framework-2 in accordance with the research strategy and thereby make a publishable contribution to the field of knowledge that is innovation in the UAE.

CHAPTER 7: ANALYSIS AND DISCUSSION

Introduction

This chapter triangulates between the empirical findings from this research, the conclusion of previous research and literature and my own sensemaking oriented towards answering the research question. Analysis is guided by the framework developed in chapter-four, itself the result of a literature review and use of Linstone's multiple perspective as a structure. The focus is on how and why UAE has been and might in future be a successful innovator of emerging technologies, specifically the lift-science, advaced servies and software targeted in *Vision 2030*. UAE, unlike most developing economies has modern (though emergent) institutions and substantial investment in education, knowledge creation and company start-ups.

Following Charmaz's (2019) constructed grounded theory, this analysis chapter supports the presenation of a framework-2 encapsulating the results of this research and summarising the contribution to knowledge in chapter-8. The methodology chapter justified the use of an exploratory research method (in this case constructed grounded theory) identifying quantitative and qualitative data with which to answer a clear set of research questions. This exploratory research gathers mainly qualitative data; the quantitative data is used to check qualitative results. This data was presented in chapters 5 and 6. Following the current chapter, a final chapter 8 answer the research questions, amend the figure 3.1 framework to take account of research findings and draw conclusions from this research by pointing out its theoretical and emprical contributions, and implicatons for poicymakers and practitioners in UAE.

As section 4.1 discussed, this is exploratory reseach since so little research on UAE's innovation ecosystem has been done; concepts, factor categories and definitions remain emergent and evolve during and as a result of the research. It is therefore primarily qualitative, though we add a small amount of quantitative data as a means of checking the veracity of the qualitative data.

Reintegration with previous literature then necessarily takes a somewhat different perspective than most of the previous literature cited. For example, previous literature on complexity and institutions can assume mature institutions or mature interactions between agents; in UAE these are emergent. This justifies the decision to undertake exploratory rather than primarily quantitative research and as Crobin (2009) notes the use of constructed grounded theory. The degree of shared destiny (acceptance and confidence in the *2030 Vision*) suggests analogies with development state literature (Woo-Cummings 1991), yet there is no applicaton of the development state thesis to a middle-eastern or resource-rich innovation ecosystem. As mentioned, much of the development literature refers to innovation systems in poor societies (or at best middle-income), whereas UAE is a rich society with high per capita incomes. It is not therefore following the 'traditional' development path (for example from agriculture to textiles to higher-value manufacturing). Hence, the nature of leapfrogging by UAE is quite different from that found in much of the development literature, such as North (1995). Another difference between the current research focus and previous literature is that earlier studies of UAE innovation, such as Ahmad (2013) and Mina (2014) focused on outcomes, whereas the present study centres on processes of innovation ecosystem change making context and culture highly significant. These processes in practice do not sit easily with the innovation/ entrepreneurship conceptual difference in academic literature (see Masri *et al* (2010), again necessitating care in referencing previous research. Finally, older development literature focuses on manufacturing industry, often leap-frogging by using the latest technologies (for example Anwar (2015); here leap-frogging is in services and knowledge-intensive products making the generation of indigenous knowledge capable of creating globally competitive products, more important that simple embedded technology transfer. For all these reasons, reintegration with previous research is not a simple, “they said that” however, “we found this” comparison and requires careful re-contextualisation making comparison appropriate to the UAE.

In assembling the data and arguments to answer the research questions (see section 1.4), this chapter additionally collects the theoretical and empirical contributions of this research. An important purpose of the chapter is to identify the major findings and contribution of this research: the big picture pruned away from cluttering by less important items. Chapter-8 which follows, takes the results of this analysis as its starting point.

Following the development of the theoretical framework (See figure 3.2), the current chapter begins by discussing the agency of innovators, proceeding to consider firm legitimacy, marshalling of resources and knowledge flows. It then discusses UAE's institutions supporting its innovation ecosystem, interactivity within the ecosystem, meta trends in innovation and meta trends in governances. This is followed by a summary of the analysis results. An alternative out-to-in analysis would begin with institutions then focus inwards on firms; however, in this case such an approach would presume answers to how and why UAE's institutions are changing, making an in-to-out approach preferable.

7.1 Innovator/entrepreneur Activity

This section highlights the findings of this research in relation to previous research in three areas: firstly, the innovator/entrepreneur relationship; secondly, the number and range of start-ups in advanced sectors and thirdly, the contribution of Emirati women in advanced sector start-ups.

7.1.1 Entrepreneurs, innovators, and Active agency

The purpose of building innovation ecosystem in UAE is to create a sustainably good quality of life for its people, remembering always that the innovators and entrepreneurs are also people. The figure 3.1 framework therefore and Linstone's (2009) TOP (technical, Organisational and personal) approach begins, with people, multiple layering (Fevolden 2015) and benefits from reflection by Delphic observers (Strasser 2018), in this case the Khalifa Fund senior managers. Of particular note to this research are people who are innovators and entrepreneurs. While conceptually, the two can be separated, the former focusing on technology and product and the latter on business-building, in practice the innovation needs to offer an entrepreneurial new solution to customers and the entrepreneur needs a product differentiated from competition. A combination of innovator/entrepreneurial agency is therefore required to successfully conquer markets, especially as Winters and Yusuf's (2007) point out, to *dance with giants*, i.e. conquer international markets. Hence the focus on innovators *and* entrepreneurs in the research questions guiding this research. All of the innovators confidently believe UAE will achieve its sustainable innovation aim; a third are under twenty-nine years of age and one-third are women. Over 40% are getting ideas from abroad and 20% from universities; in 74% of cases, the innovator/entrepreneur is leading the business (see section 6.1).

Literature such as Al-Naqeeb (1990) speak of an *articulated spirit* of entrepreneurship amongst Emiratis and a commitment to seeing benefit in education (Alkhateeb 2014) and private sector growth accompanying economic diversification (Ogbonna 2018). Evidence from previous research on Emirati innovation start-ups is mixed. GEM points to the high rate of employment by start-ups in Dubai (42%), while Dubai SME (2013) suggests many start-ups are foreign owned or trading rather than technological firms. Hameed *et al* (2016) suggests that only 3% of UAE start-ups feature advance technology products. However, 3% of UAE's 72,000 SMEs (Gundala and Khawaja, 2014) figure, suggests 2,160 hi-tech firms – a considerable number given the population. This accords with Phan's (2004) argument that the UAE's innovation system is successfully creating innovative firms. UAE's later entry into these markets is proving an advantage, for example in adopting Cunningham's (2019) entrepreneurial university perspective and with the opportunity Zahra *et al* (2020) highlight of filling gaps in existing innovative ecosystems.

Perhaps unsurprisingly, the innovators and innovation policy interviews (see section-5.1) would also agree with Phan's conclusion, qualified only by policy and incubation interviewees being unable to name a 'star' start-up firm. Amongst the interviewees there is no support for the conclusion of Al-Waqfi and Forstenlechner (2012) and Erogul (2014) that young Emiratis are risk-averse and prefer to take 'safe' sinecure employment with the Government. Not having conducted a whole population survey the evidence on this matter cannot be considered as conclusive, however, rich investigation of active agents, exploring what they have done and why, offers alternative datasets with which to answer the research questions. This point is apposite, given the lengthy period Audretsch (2014) notes is necessary to build up entrepreneurial capital (knowledge) and the lengthy period needed to create effective commercialisation from research universities (Fuller *et al* 2019).

7.1.2 Women in UAE innovation

Several researchers point to an unrealised potential of women as employees and innovators in UAE including Doumato (1999), Hertog (2010), Davidson (2011) and Al

Khayyal (2020). Energised by a high university enrolment rate (as Al-Oraimi [2011] notes, 70% of Emirati graduates now are women), in recent years women's labour market participation has risen, reaching 40% in 2016, according to WB (2016) and Tlaiss (2014) found an erosion of cultural barrier to Emirati women's entrepreneurship. Though Majumdar and Varadarajan (2012) suggested that Emirati women lack an entrepreneurial culture, this finding is contradicted by Sowmya *et al* (2016) who find that 70% of young Emirati women want to start their own business, which is above the international average of 60%. Section 2.3 details the burgeoning range of women's business networks in UAE and the example of Princess Al-Madani's (2017) successful business. As Marmenout *et al* (2014) Emirati women are increasingly talented, making it all the more important that their contribution to a diversified economy materialises. Institutional arrangements and culture appear to be supporting women's business foundation and not acting as a barrier. As section-6.1 reveals, 29% of the survey sample were women innovators represented as 30% in non-carbon, life-science 12% and software 50%. Almost all had graduated from incubators, such as R-11. Ergul and McCrohan's (2008) research suggested that Emirati women are less motivated by extrinsic reward (only 25% mentioned money) and instead by independence, contribution to society, self-improvement and professional development. While this research focused on product and technology rather than motivation, the research finding that 29% of advanced sector start-ups are led by women, (there is high-risk of failure), suggests support for Ergul and McCrohan's findings. The important conclusion from this research is that in advanced sectors, women are finding less, if any, cultural or institutional barriers to launch new businesses and in particular are proving capable of innovating in the advanced sectors targeting in *Vision 2030*. It appears that opportunities for new business models (Rauter 2017) and online business opportunities particularly suit Emirati women.

Table 7.1 summarises the results from this section showing that although innovator and entrepreneur are conceptually separate, in practice the roles combine. The evidence also suggests that Emiratis in UAE are establishing firms in advanced sectors at a significant rate. Though it is not yet clear if any will be sufficiently successful in international market to meet the *Vision 2030* gaol, at this stage in development the prospect of success cannot be discounted. Finally, the evidence shows that young Emirati women are not inhibited by cultural or institutional barriers from successfully innovating in advanced sectors.

Research finding	Previous research supported	Previous research disputed
Innovators and entrepreneurs are often combined roles	Mitchell (2009) Audretsch (2014); Utterback *et al* (2019)	Lewin et al (1999) and Anderson (1990); Hameed *et al* (2016)
Articulated spirit of Emirati entrepreneurship is strong in advanced sectors	Phan (2004); Cunningham *et al* (2019)	Hameed et al (2016) Dubai SME (2013)
Young Emirati women are actively starting up firms in advanced sectors	Ergul and McCrohan (2008); Tlaiss (2014); Marmenout *et al* (2014) Dutot *et al* (2015)	Davidson (2011) Majumdar and Varadarajan (2012) Al Khayyal (2020)

Table 7.1: Research findings relating to Emirati innovators in advanced sectors

7.2 Firm legitimacy

Successful innovative firms rely on legitimacy in the eyes of customers, suppliers, partners, and financiers in addition to standards compliance including legal, accounting, regulatory and technological (Shane 2004). Researchers such as Sarasvathy and Venkataraman (2009) combine legitimacy with the marshalling of resources as the principal prerequisites for innovative firms. Often legitimacy research is framed in terms of stakeholders; Rodriguez Pose (2013) and Warwick (2013) are examples and in developing economies as creating 'space' for open innovation; see Kantis and Federico (2012) and Feld (2012). Isenberg (2011) views firm legitimacy as layered between firm-level, sector and national innovation systems. Recently, Mason and Brown (2014) have used the idea of innovation ecosystems and Stam (2015) has begun to explore the idea of ecosystem in developing economies, though not from the viewpoint of innovations in emergent sectors.

In one sense therefore this research synthesises Mason and Brown's use of ecosystems to understand innovation legitimacy and Stam's idea that legitimacy in developing societies differs from that expected in developed environments. Legitimacy of innovations is problematised here as taking on particular and special meaning in a rapidly development ecosystem such as UAE where categories such as intellectual property law, growth rates of internationalising firms and dynamic capabilities of institutions are fluid and emergent. Additionally, legitimacy takes on particular characteristics in emerging sectors, where (for example) asset values, net present values and unforeseen barriers/enablers are also emergent. Stinchcombe's (1965) *liability of newness* takes on quite different dimensions for emergent sector innovations in emergent economies. These points are central to national systems theory (Carlsson and Stankiewicz 1995) and triple helix theory (Etzkowitz (1983), which suggest universally applicable variables fail to suitably account for differentiated innovation contexts: in this case emergent technologies in emergent markets. Here legitimacy is rooted in this particular culture and the context of UAE (see table 3.2, table 3.3 and 3.4) in addition into being a factor shaping the innovation's growth path; for example, legitimacy as a partner in international R&D networking and/or supply consortia.

Evidence from the survey (section 6.1) shows 40% of firms trading at over 11-million Dirham per year and 51% having over ten staff. Half of the companies receive financial support from banks. Almost all of the twenty-seven companies sought the legitimacy of market research prior to launch (29% using marketing consultants), with 73% (figure 6.13) saying that customer voice is important. Twenty companies used an existing online platform as a market entry strategy. 60% say that compliance with international standards is important, 70% report complementarity as important and the same number having international partners (figure 6.14). Figure 6.16 summarises evidence of the importance of firm legitimacy from the perspective of innovators. This includes compliance with UAE law in the form of company registration and international accounting standards and intellectual property law.

Legitimacy is important to Emirati innovators and in manner used by Mason and Brown (2014) and Stam (2015) readily achieved with an emphasis on international legitimacy in the form of sales and staff. Section 5.2 suggests that achieving legitimacy as innovators may be easier than gaining legitimacy as entrepreneurs for university spinouts, who find cementing trading relationships with existing UAE firms difficult (see table 5.4) a contrary experience seems to face the firms internationally, where trading and standards compliance (entrepreneurship) appears less problematic than being taken seriously as innovators. For example, firms quite capable of selling products Compagnucci *et al* (2020) are unable to join international product knowledge networks. This is Audretsch and Belitski's (2021) point: membership of international product development networks is critical, or the alternative is being "designed-out" of production and future development. Is it possible to succeed in terms of international legitimacy as an entrepreneur but not as an innovator?

Legitimacy within innovation ecosystems takes different forms in emerging economies (asset values, network connections), an additional *liability of newness* surrounds asset values and assessment of capabilities as participants in international knowledge networks. It is easier, for example, to join public knowledge networks than those developing next generation products. UAE companies, especially in software have the future-orientation Haegeman *et al* (2012) deem important, and legitimacy in the eyes of Emirati universities, more effort is needed to trade with major companies (Bonus 2019) and as Simon *et al* (2019) emphasise to become members of international research and (later) product and service development networks. As table 7.2 illustrates, these conclusions refine previous research to take account of the nature of emerging market innovation ecosystems.

Research finding	Previous research supported	Previous research disputed
Innovation ecosystems often combine roles of innovators and entrepreneurs	Mitchell (2009)	Shane (2004) Sarasvathy *et al* (2009)
Legitimacy comes from market and customer orientation, especially if trading with existing large companies and membership of international product development networks; internal legitimacy (e.g. with universities) is insufficient	Bonsu (2019) Compagnucci *et al* (2020); Simon *et al* (2019)	Aksoy and Beuadry (2020)
Ecosystems rely on firm legitimacy, which in emerging economies takes forms different from those in developed economies	Arthur (2015) Haegeman *et al* (2012)	Mason and Brown (2014) Stam (2015)
Liability of newness different in emerging innovation ecosystems than mature ecosystems	Holland (2015) Audretsch & Belitski (2021)	Stinchcombe (1965)

Table 7.2: Research findings relating to Emirati innovator legitimacy

7.3 Marshalling Resources

Industrial diversification, the recipe recommended by Sachs and Warner (2001) to avoid the rentier state mentality, informs but insufficiently captures UAE's *Vision 2030* strategy which takes the more challenging goal of building a sustainably innovative ecosystem capable of joining the elite group of developed societies. In traditional development theory (for example North 1990), scarce resources for education, research, business development and infrastructure are a major problem, often resulting in unsustainable borrowing, currency fragility and loss of sovereignty to bodies such as the World Bank and International Monetary Fund. UAE is an exceptional case: a rapidly emerging economy that already has the resources to support development (and high incomes); the point is does the ecosystem funnel these resources to points where they can be marshalled by innovators to create the capabilities and capacities necessary to support innovation in advanced technological sectors? Effective innovation ecosystems enable the marshalling of resources (Harrison 2002), tangible and intangible (Haskel and Westlake 2018) to innovate new solutions for customers F3 and F12 in table-3.3 and a thematic group in table-3.4). Making the point that holistic stories of innovation cannot exclude fund, Shiller (2019) and Audretsch and Belitski (2021) point to uncertainly over time, highly problematic in the case of UAE's non-carbon, software and life-science target technologies, which can have a long gestation period as the data illustrates, drawing attention to the quadruple-helix (Van Geenhuizen 2019). For example, pay-back on solar technologies can be lengthy and the product (electric energy) difficult to export ((Zhang *et al* 2019; Oliver *et al* 2020); Meng *et al* 2020). Similarly, IoTs software presumes target markets bearing the high up-front costs of 5-G installation as Bosch (2019) note. The point is that UAE's target technologies are associated with lengthy gestation and high upfront costs, adding risk.

Previous research on Gulf innovation, such as Al-Naqeeb (1990), Al-Waqfi and Forstenlechner (2012) and Al-Ansar, Xu and Pervan (2014) focus on start-up numbers. This research is focused more on the processes leading to successful innovation and therefore endogenous knowledge creating, attracting of international applied researchers and membership of international knowledge networks are especially important resources to be marshalled. As new sectors grow in emerging ecosystems, it cannot be assumed as Etzkowitz (1983) does those existing interplays between universities-Government-business will effectively support innovation; for example, entirely new business models (Zott and Amit 2007) including types of funding are likely to arise (as Schumpeter 1934) suggests. This is perhaps especially so where the new products are (intangible) services i.e. often without firm-specific physical assets (Subramanian 2014). This is why section-3.1 criticised *logic models* such as the Triple Helix and National Systems: in emerging sectors and emerging economies it cannot be assumed that yesterday's innovation process in other contexts, will be adopted today in a different context. An associated point therefore is that an ecosystem capable of supporting advanced sector innovation will be characterised by an education system producing advanced human capital, advanced basic and applied research (Owen-Smith 2002; Howells 2006) and university-industry links supporting university spinouts (Schiller 2008). Jones *et al* (2020) emphasise knowledge mobilisation as a key resource. At the moment UAE companies are only emerging as partners in international product development networks: exclusion involves exclusion from the knowledge bearing future commercial fruit. Without new knowledge to add, UAE companies may have to 'buy' entry tickets into knowledge networks to gain the knowledge necessary to join future networks – a sunk cost only bearable by highly capitalised and/or publicly subsidies companies. Cai and Cui (2015) and other point to knowledge flows, the evidence here also emphasises the cost of knowledge flows.

Section-6.3 shows firms generating their own proof of concept funding and often relying on sales receipts for working capital; evidence that 'mature' banking arrangements are unavailable to emergent innovation systems (see figure 6.17). This is despite Emirati banks holding funds 150% of GDP from personal accounts and existing companies. Invariably assessing applications for facilities from start-up companies in terms of current physical assets, rather than future earnings potential, UAE banks reject 70% of SME credit application, according to the IMF (2015). This absence of working capital perhaps explains the low level of international sales by UAE SMEs: as figure-6.20 shows, only 11 to 20% of sales are international. In the absence of bank facilities, half of the SMEs 'burn equity' and take on outside investors, a third offer staff equity stakes (figure-6.19; which may be a cost-reducing strategy). 40% of the firms surveyed are cost-sensitive – high for hi-tech ventures.

Table 7.3 summaries issues facing firms in emergent innovation ecosystems, centring on the point that where such ecosystems are born within emergent and immature institutions, such as banks and the finance sector generally, the firms face quite different issues in marshalling resources than in mature institution contexts.

Research finding	Previous research supported	Previous research disputed
Diversification an inadequate goal for sustainable innovation ecosystem.	*Vision 2030;* Shiller (2019); Audretsch and Belitski (2021	Sachs and Warner (2001)
Knowledge flows important, also, the cost of knowledge flows now, for later benefit are important: cost of UAE 'entry tickets' to international knowledge networks	Jones *et al* (2020); (Zhang *et al* 2019); Oliver *et al* (2020); Meng *et al* (2020)	Cai and Cui (2015)
Stages in traditional development theory can be leapfrogged by resource-rich emergent innovation systems.	Johnson (1985) and development state theorists	North (1990)
Emergent institutions for marshalling resources differ from mature institutional arrangements and logics assumed.	Woo-Cummings (1992) Van Geenhuizen (2019)	Etzkowitz (1983)

Table 7.3: Research findings relating to Emirati innovator marshalling of resources

The firms buy-in 60% of product content, suggesting high costs (which may be overcome by high margins); an important proportion if this is imported knowledge content, the issues around which are in the following section.

7.4 Knowledge flow activity

For earlier phases of technological innovation, Gerschenkron (1966) pointed to the possibility of late entrants adopting the latest technological systems and thereby arming themselves with competitive advantage. In relation to more advanced technologies, Christensen (1999) developed the idea of disruptive technologies and new solutions to customer's problems. Chadran *et al* (2020) makes the point that there is no short-term fix in building research capabilities. They argue that 'trophy' Professors expensively transferred from abroad, even where they take their job seriously, require several cycles of PhD students (perhaps ten years) before they can constitute internationally recognised research centres. In these advanced sector late-entrant (potential disrupters) cannot leapfrog simply by transferring-in the latest capital equipment. Instead, endogenous knowledge creation becomes a key resource to marshal; knowledge for such technologies cannot be endogenously sought precisely because no competitor company/country will share the most advanced technological knowledge out of fear of being themselves disrupted. Knowledge product therefore require knowledge workers with the absorptive capacity to understand and exploit exogenous knowledge, the capability to conduct break-through basic research and applied research abilities to help exploit new knowledge (Lee 2013). Only with these capabilities will innovation ecosystems produce agents welcomed into international knowledge networks (product development or supply) targeting the next generation of technological innovations. These capabilities arise from a high-level education system, universities and corporate R&D and involve both tacit and formal knowledge flows, the importance of which is illustrated by fifteen of the forty-three factors constituting an innovation ecosystem relating to knowledge flows (see table 3.2 and 5.7; the evidence for which is summarised in table 5.8. UAE does have strong capabilities, for example in medicine and oil and gas, Leydesdorff and Ivanova (2020) argue for *synergy indicators* – the extent to which other departments learn from those already successful and seek opportunities to work with them.

7.4.1 Education system

As discussed in Section 1.1.3, previous research on the Emirati education system, noting a well-funded K-12 programme with high literacy levels serving 650,000 school pupils (Lapidus 2012), now 80% of all girls complete secondary education (GEM 2019). While as Alkhateeb (2014) notes Emirati education is rapidly changing, Programme for International Student Assessment (PISA) scores remain in the bottom third, for example at 453 in maths and Leydesdorff (2020) points out only 22% of university students study maths and sciences. Hameed *et al* (2016) and others accept the inappropriateness of the traditional rote learning model, advocating more problem-centred learning, encouragement of creativity and as Ashour (2016) recommends, entrepreneurship education. In the World Economic Forum's Global Competitiveness Index UAE ranks 12th, alongside the UK, with its major drawback on the index being quality of education. As Wolf (2002) there is no simple linear relationship between education and an innovation ecosystem, however it does influence overall absorptive capacity; a point *Vision 2030* recognises. Khalif Fund Chair, Hussein Jassim Al-Nowais too (2015) accepts the priority of improving Emirati education, which R-3 says currently takes 21% of the Government budget. One consequence of high state dependency by universities is that contrary to Toan's (2021) suggestion that only Asian universities can be guided by Government, this high level of state support in UAE should make it easier to reorientate universities towards helping to meet Vision 2030 objectives. The company survey (figure-6.34 suggests that companies support this prioritisation and while Education Officials interviewed focused on university-level education R-2 for Research emphasises improving the quality of education for all young people pointing to TIMMS global assessment figures, and R-2 from the need to move up international rankings, noting the correlation between HE and economic development Abdurakhmanova *et al* (2020) found.

In summary, UAE's school education system is much better endowed than that in most developing ecosystems; the need for improvement is widely recognised and prioritised: the challenge to improve performance lays ahead.

7.4.2. University knowledge flows – teaching and research

Emirati universities, like those in other developing societies are transitioning from teaching-only towards a remit also including research and commercialisation; in short from information transmission towards organisations capable of generating, disseminating and exploiting knowledge. Kirk and Napier's (2009) study of UAE universities concludes that a mix of investment in outward international study alongside international faculty recruitment is UAE's best route to basic research. However, they note that the current ratio of one-third international faculty remains low by top international standards. Already UAE's eighty-six HE institutions include top-400 Universities (UAE University, Zayed University, Khalifa University, American University of Sharjah and University of Sharjah) with research centres including space science, health sciences, Genetic Engineering and Biotechnology.

UAE universities are improving teaching; 60% of students are women (80% being first generation graduates according to Sowmya *et al* 2010), however, he goes on to criticise tradition pedagogy (rote memorisation, knowledge-domain rather than problem-centred assessments). More positively, departments such as oil technologies and medicine are successful and as Leydesdorff (2020) points out can be better used as exemplars for UILs and applied research projects. UAE's new evaluation framework (Jones 2020) can be used to reorient universities, especially given their dependency on state support (Chahine *et al* 2009), perhaps meaning insistent policy implementation where universities resist change.

The balance between basic and applied research in universities fails to support the emergent innovation ecosystems. Jabeen *et al* (2016) recommend more HE more links to business; we find mostly interested in publications and patents not applied research. This situation may be different in oil-related and medical technology research and technologies.

7.4.3 University commercialisation

Howells (1993), Owen-Smith et al (2002) and Eisenhardt (2005) along with many other researchers of commercialisation and university-industry links (UILs) argues that bridging the gap between science and technology by creating new products is a challenge in all countries, all disciplines and for all research universities. Ross (2016:64) is surely quite wrong to suggest,

> *There are three things necessary to create breakthrough advances in the life science: great scientists, lots of capital for academic research, and a venture capital market to help turn academic research into commercial products.*

There is no linear progression from invention to innovation and then entrepreneurial success. Knowledge spill overs, El-Obeidy's (2013) research across the Arab region suggests arises from lack of university priority and shortage of leaders capable of linking research to product innovation. He concludes that Arab universities should therefore focus on alliances with international companies, with proven capability to commercialise research. Alternatively, Hameed et al (2016) who suggests that only 3% of UAE start-ups deploy advanced technologies, argues that UAE universities should concentrate more on business education in all disciplines, while Guerrero and Urbano (2012) note the paucity of studies on commercialisation. Government policy, expressed in Vision 2030 and R-21, favours incubators as bridging and shortening the science-technology gap.

The conclusion of chapter 6 concludes that the evidence of this research is that UAE universities, in the three target sectors on which this research focuses are not successfully commercialising research. In other sectors such as oil and gas, architecture or medical devices different conclusion may be possible. R-18 (section-5.4) from University suggests the universities focus on patenting and published instead of commercialisation the binary alternatives to which Bich *et al* (2021) point. R-1 from the Education Scientific Research Department agrees, advocating incentives for applied research, a policy Gan *et al* (2020) found that was successful in China. R-2 from the Scientific Research of Education and Knowledge believes *one or two* universities are successfully commercialising but offers no examples. He goes on to argue that lack of commercialisation is the major risk facing *Vision 2030*. Few Emiratis, according to Melley (2010) choose vocational degrees (only 13% take science subjects) and many university researchers simply do not see commercialisation as part of their role (Guerrero and Urbano 2012). The survey reveals that 65% of innovative companies employ staff with higher degrees, however only six of the twenty-seven companies claim links with universities and of these only five say they do some joint R&D.

From Etzkowitz's (1983) Triple Helix perspective significant Government investment in research (including transfer-in of international researchers) and incubation facilities exist, with support for business development from the KF and other agencies; an initiative in line with Hayter's (2015) suggestions. Returning to the three proposals to increase commercialisation mentioned above (international company alliances, entrepreneurship education and incubation), the immaturity of each, from the viewpoint of the emergent innovation ecosystems, evidences the inapplicability of TH theory to emerging innovation contexts.

7.4.4 Corporate R&D

At first sight, overall UAE spend on R&D, including corporate spend is low at only 0.7% of GDP against an OECD average of 2%; however, given the inflated level of UAE GDP from oil revenues, its R&D figure is substantial. Yet how focused is the R&D spend towards innovations offering commercial success. Edvardsson et al (2006) and others emphasise that the importance corporate leadership is R&D is that companies privilege commercial (and profit) outcomes as a mobilisation of bias. Thus, in terms of impact corporate-led R&D may contribute to sustainable innovation in more focused ways than public-funded and led research centres. For companies, Howells and Wood (1993), unless they have disruptive technology and are capable of successfully negotiating disruption of market leader incumbents the best strategy is membership of international R&D networks aiming to continuously improve supply chains or develop next generation products. From this perspective, key issue arising from UAE's goal of a sustainable innovation ecosystem is then the extent to R&D-oriented firms are members of such purposive international knowledge networks.

As figure 6.15 illustrates, 56% of innovative firms say that membership of international R&D networks important, with 64% of the twenty-seven firms (figure-6.27) saying that they are members of such networks and 72% (Q-56) saying that they have absorptive capacity to participate. All twenty-seven firms say (figure-6.30) that they have an innovation pipeline. These figures suggest an auspicious future for UAE corporate R&D in the target sectors. However, closer inspection reveals a more ambiguous picture.

The knowledge flows cited in section 5.4 are mainly formal, as R-17 and others comment UAE R&D is weak in transferring tacit knowledge (the "how-to" of innovation) since there is little interaction *with businessmen personally*. Evidence from the (R-11), for example, suggests a focus on intermediate goals such as patenting: the centre has no entry criteria (such as nearness to market) and no exit criteria (such as successful commercial launch). Although there is substantial public investment in attracting international researchers to universities and into incubation units, people-carried knowledge too tends to be formal and not applied, as R-6 from the international trade points to "*levels of under-performance in Technology and Life Sciences in UAE*". A similar story unfolds for organisation-carried knowledge, with respondents in section 5.4 bemoaning lack of commercialisation commitment in Emirati universities despite staff transfers, showing little sign of Cunningham *et al's* (2019) *entrepreneurial university*. Importantly, as R-17 notes, incubation units are headed by academics and not experienced businesspeople and there is little interaction between successful trading businesses in target sectors and incubating projects. R-1 says, "*The problem lies in the awareness of private companies".* Asked to give example of international knowledge networking, R-12 list foreign international bodies such as MIT, AK in Japan and Fraunhofer. R-14 confirms this pointing to "*no success stories to date".* Yang *et al* (2021) are clear that in UAE's target technology areas, wide ecosystems, including university are necessary – evidence of these is at best only emergent in UAE. It may be that other problem exist, (R-16 points to lack of funding and R-15 to a shallow pipeline of projects), however, the evidence is clear: despite significant public investment, UAE corporate and university commercialisation units have little if any involvement in international knowledge networks creating next generation products. Schwab's (2013) suggestion of linking university to the establishment of applied, cross-governance research centres, appears apposite.

Examining knowledge flows in UAE's nascent innovation ecosystem presents a mixed picture summarised in table 7.4. There is a modern and modernising school system, successfully educating young Emiratis, though not yet at world-leading standards in science and technology subjects and remaining too dependent on traditional pedagogic techniques that hinder creativity. Universities are not focused on vocational or science subjects, teaching using traditional pedagogy and favour publishable or patentable basic research above applied research; little R&D is done jointly with Emirati or international companies. While levels of corporate R&D spend appear high and advance technologies companies recognise the desirability of participating in international knowledge networks, there is little evidence of participation in international knowledge networks creating next generation products – a key finding of this research.

Research finding	Previous research supported	Previous research disputed
Schooling good, but needs reform to achieve best international standards	See R-3	Lapidus 2012
Old pedagogy and low entrepreneurship education	Hameed et al (2016)	Alkhateeb (2014); Hayter (2015)
Universities internationalising	Kirk and Napier's (2009)	
University traditional teaching	Sowmya et al 2010	Masri *et al* (2010)
Few business links	Jabeen *et al* (2016); Leydesdorff and Ivanova, 2020; Baglieri *et al* (2019)	
No narrowing of S&T gap	Melley (2010); Jones *et al* (2020); Abdurakhmanova *et al* (2020)	Bich (2021
High level of R&D spending contrary to Howells' findings	Howell (2006); Chadran *et al* (2020)	Howells and Wood (1993)
Focus on formal knowledge flows not applied/commercial: need for Government to lead change of direction of universities	Howell (2006); Toan (2021); Gan *et al* (2020); Schwab (2013)	No previous research on balance of tacit/formal knowledge generation in UAE start-ups Guerrero and Urbano 2012
Little membership of international innovation knowledge networks (in target technologies) due to lack of R&D capability	Howells and Wood (1993); Yang *et al* (2021); Oliver *et al* (2020)	Howell (2006)

Table 7.4: Research findings relating to knowledge flows

7.5 UAE institutions

An innovation ecosystem has an institutional framework supporting sustainable innovations in advanced sectors trading competitively in international markets and supporting high incomes. Data and analysis illustrate, as Fevolden 2015) notes, the benefit of adopting Linstone's multi-layered perspective. In (Winters and Yusuf's (2007) phrase, to *dance with giants* suggests Dubai means join the elite group of perhaps thirty counties, twenty global cities with sufficiently *thick* socio-economic institutions (Amin, 1994) featuring interaction between technical, Organisational and personal (Linstone, 2009): this is Mazzucato's (2013) entrepreneurial state: actively supporting innovation and notably doing so not by haphazard actions, but as the KF evidence shows, informed as Haegeman (2012) recommends, by a long-term strategy: Vision 2030. An important element of dancing with giants is SME learning from large companies, this include inward FDIs. Complexity dominates such interactivity as active agents (Archer, 2011) react to events and the decisions of others, open to ideas and responding to challenges (Sennett, 2017) by innovating products and dynamically remoulding institutions. A culture shift associated with these changes, promoted by the Government encourages 'heroic' entrepreneurs, as opposed to the traditional aspiration of a 'safe' public sector job. In UAE's case, emergent institutions currently provide high living standards based on oil revenues (Ahmed and Alfaki, 2016), avoiding the *curse of natural resources* (Sachs and Warner 2001 however, the middle-income trap facing all emergent innovation ecosystem remains (Bulmer, 2014); to create and use institutions capable of sustainable to innovate (without oil revenue): this is the UAE's *2030 Vision* – a challenge Owen-Smith (2002). In this sense, UAE's institutions are unusual: they have the latecomer advantage (Zhang 2019) of successful examples *and* the resources to invest heavily in their operationalisation. Howells (2006) and Sennett (2016) argue that revolves around participating in and exploiting endogenous and international knowledge flows.

Skok and Tahir (2010) note that no Arab or Gulf country has successfully migrated to become a sustainable innovation ecosystem; there are perhaps thirty to forty countries currently in the middle-income trap wishing to make this migration. From an analysis of literature on innovation ecosystems, Table 3.3 presented forty-three factors constituting an innovation ecosystem, condensed under four thematic headings in table-3.4 referencing Linstone's (2009) TOP approach and illustrated as an analytical framework in figure 3.2.

Factor	Evidence of factor presence supporting innovation ecosystem in UAE software, life-science and non-carbon technology
F1: Online presence + tools	Online presence important for sales, little use of tools
F2: Links to UILs/SSIs/Firms	Weak UILs, little sectoral identity, but firms in each target sector
F3: Fund and partners	KF well-fund, well-known – playing (partial) leadership role
F4: Linkages to MoU agencies	Yes, strong evidence of agency interactivity
F5: Business led incubation facilities	No, academics lead incubators not businesspeople
F6: Business support staff	Yes, how much used?
F7: Links to firms and mentors	Little
F8: Proof of concept support	Use own funding, incubator support but without business links
F9: Market entry and growth	Successful entry, often using foreign platform
F10: Product and its R&D	Often imitation or low knowledge content, some ….
F11: Process technology	Successful, cost control, 40% home made
F12: Risk capital	Yes. Banks risk-averse; question marks over funding
F13: Leverage, bank facilities	Little: see section-7.3
F14: Costs and their control	Yes: see for example R-16 and figure 6.18
F15: Supply + logistics	Stable currency, WTO and bi-lateral trade standards
F16: Leadership	Yes, especially young
F17: Staff and partners	Qualified staff, migrants; often partners international
F18: Useful knowledge flows	Some, mainly formal
F19: Education standards/ staff training	Need to improve education standards; little vocational education
F20: Reputational capital	High: existing clusters, no corruption, quality of life
F21: Business professionals (inside firm)	Abundant, see figure-6.17
F22: Business mentors	Little especially at start-up stage
F23: UILs, company R&D links	Weak linkages between universities and indigenous businesses in non-oil sectors
F24: Media representation	Good PR
F25: Big company learning	Little learning in non-oil and finance sectors from IFDI or international partners
F26: Business mentors	Major shortage of mentoring for start-ups and incubation centres
F27: Business networks, customer voice	Low level, yes listen to customers
F28: Entrepreneurs' legitimacy	Yes, In eyes of staff, customers, suppliers, banks etc entrepreneur is legitimate
F29: Business professionals (in SSI)	Yes, figure-6.17
F30: ICT infrastructure	Yes, good quality infrastructure, figure-6.29
F31: Regulations: IP, Tax	Yes (tax issues)
F32: Logistics infrastructure	Yes, figure-6.14
F33: Rule of law/no corruption	Yes, no reports of any corruption 100% agreed no corruption in advanced firms
F34: Policies: grants, business friendly	Yes, most innovators and Officials satisfied figure-6.17
F35: Exit market	Informal, private sale
F36: Effective labour markets	Yes. Women. Migrants BUT youth unemployment
F37: Open expert migration	Yes, but formal knowledge, less business expertise e.g. Incubators
F38: Clear international standards	Yes, figure-6.14 suggests enthusiastic adopters
F39: Routes to connectivity	Exist but not successfully used
F40: Complementarities	Yes, see figure-6.14
F41: Inward FDI learning opportunities	FDI but little in these sectors; little learning
F42: Involved in R&D networks	Titchy bit
F43: Staff with absorptive capacity	Apparently

Table 7.5: Evidence of innovation ecosystem factor presence in UAE

Table 7.5 brings together a summary of the metrics uncovered by this research in relation to each of the forty-three factors, drawn from the first four sections of this chapter. The table portrays a promissory picture of UAE's emerging innovation ecosystems in the three advanced technologies chosen as targets. Without going into detail, the physical infrastructure, research universities, availability of funds, quality of education and well-resourced national institutions would be the envy of other emerging economies. In these areas, which are physical and resource-dependent UAE's innovation ecosystem appears healthy and ready for growth. However, as further analysis will show, in the intangible and knowledge-based areas of activity deeper analysis shows significant challenges facing UAE's innovation ecosystems.

Table 7.6 uses the themed factors (in table 3.4) above to summarise the relationship between UAE's emergent innovation ecosystems and the institutional context in which they are striving to flourish.

Thematic groups of factors	Factors	Overall picture of UAE's innovation ecosystem
Innovator/ entrepreneur (agency)	5 6 8 10 11 16 27 30 31 32 33 38	• Ecosystem has successful clusters (innovation hub, culture, property) using international standards, business-acceptable law, tax and IP, no corruption, good ICT and logistics infrastructure providing online presence and sales (little used toolkit). • High women's rate of innovation and company start-up in advanced sectors. • Incubators weak in business interactivity, proof of concept self-funded, products often imitative or dependent; leadership and management skills to establish and operate businesses, would value international network presence but not yet achieved.
Legitimacy	1 4 9 15 20 24 28 35	• Within UAE agencies work together, firms are successfully launching in advanced sectors achieving legitimacy with national and international partners; firms enjoy high reputational capital and media presence.
Marshalled resources	3 12 13 14 17 34 36 37	• Public and private funding are available, though banks are risk averse. Business professionals available in supportive business environment featuring effective labour markets for Emirati and migrant labour providing start-ups with qualified staff and absorptive capacity.
Knowledge flows	2 7 18 19 21 22 23 25 26 29 39 40 41 42 43	• Staff have absorptive capacity, connectivity and complementarities, • Company and business links weak during incubation, knowledge flows with firms and networks weak, problems in education system, university research and commercialisation and incubation; not in international knowledge networks or inward-FDIs • Unclear if SSI delivers anything

Table 7.6: Overall picture of UAE's innovation ecosystem as evidenced in this research

The Table shows that it is in intangible areas of activity that the institutions provide weakest support to the innovation ecosystems: such as knowledge creation and exploitation, especially participation in international knowledge networks; also, areas such as marshalling financial resources using banks. There are however strengths, of particular note, are the sophisticated ICT and logistics infrastructure, large number of women innovators (related to university education), the availability of incubators, acceptance of the *Vision 2030* and coordination between national institutions and attractiveness for international professionals of working in UAE, including high standards of personal services resulting from the average high salary levels. Table-7.7 shows the relationship of these findings to previously published research.

Research finding	Previous research supported	Previous research disputed
Thickness of institutions important especially trust	Amin (1994); Haegeman (2012); Fevolden (2015)	Sikdar (2011)
Limited learning from large companies (partners or IFDIs)	Howells (2006); Mazzucato (2013)	Winters and Yusuf (2007)
UAE a special case of institutions based on developing economy/society BUT already high incomes	Zhang (2019); Chamberlain and Kalaitwi (2020)	Ahmed and Alfaki (2016)
Importance of human capital quality, including vocational education for ecosystems	Fasano and Iqbal (2003) Hertog (2010); El-Sokari *et al.* (2020)	Al Nuaimi *et al* (2019)
Compliance with international standards e.g. IP law	Davidson (2011)	Skok and Tahir (2010
High % of advanced technology innovators are women	Ergul and McCrohan (2008)	Majumdar & Varadarajan (2012)

Table 7.7: Research findings relating to UAE institutions

7.6 Interactivity in the UAE's complex innovation ecosystem

Inspired by Linstone's multiple perspective theory including his later work (2009) calling for the application of concepts from complexity theory, this research has identified the strengths and weaknesses of UAE's innovation ecosystem in three target technology sectors: software, life-sciences and non-carbon. Section-7.5 illustrates that the successful areas of ecosystem-building are in the physical and top-down aspects such as building infrastructure, legislating, providing grants and capital, hiring in universities. Weaker aspects of the ecosystem are intangible and invisible, especially knowledge-flows within and from outside of UAE and between researchers and business. The figure

3.1 framework was constructed to analyse the dynamic aspects of the ecosystem, particularly in this case, the factors constituting factor in theme 6 in the middle bottom of the figure. Using the forty-three factors derived from previous research, the framework poses the question of how, by what processes the 'old' ecosystem migrates into the 'new.' Framed in terms of section 7.5 conclusions, what is it and how can the institution be thickened. In UAE's case, with existing vibrant ecosystem (air transport, culture and property), also with significant investment resources and high income (and domestic demand) levels, the answer to this question will be framed in highly situated terms: UAE is quite unlike other developing innovation ecosystems at the same stage of development. Ranked 12th in the World Economic Forum's Global Competitiveness Index, Vidican et al (2016) suggest UAE can create new sectoral systems of innovation, in areas such as solar energy generation and the IMF (2016) says it is the most *economically complex* of Arab oil states. Finer grained analysis however identifies challenges for the UAE to achieve its sustainable innovation vision. This section explores evidence of interactivity with the ecosystem by (a) agents responding to events and decision within UAE; (b) the quality of international interactivity at firm level; (c) the interactivity associated with the leadership role of the KF and (d) interactivity between levels of scaling.

7.6.1 Interactivity within emergent innovation ecosystems

Putnam's (1981) socio-psychological ideas centred on social capital, (with derivative ideas on cultural capital and occupational capital), supports to social network mapping, which could be a useful approach to charting interactivity in an innovation ecosystem. A shared cultural capital clearly exists in the form of every single respondent knowing of *Vision 2030* and most believing it can be achieved.

Studies since Castells and Hall (1994) and Toumi (2002) have shown that social dimensions are important to *untraded dependencies* (trust-based externalities) in cluster-building. Overall, as section-6.6 illustrates interactivity in the form of university-industry links (UILs) appear weak in UAE: there is little shared applied research and business interaction with university incubators is shallow. This is evidenced in section 5.4 (see table 5.8). For example, R-17 who helps manage the Department of Technology, further notes that "*researchers and incubates have little interaction with businessmen personally, but with companies that may deal with them"*. However, the business sector does illustrate the sorts of interactivity Geels (2006) suggests are characteristic of vibrant sectoral sectors of innovation (SSIs), represented in figure 2.2. These are evidenced in the positive feedback loops reported (section 6.6) by innovative companies with customers and suppliers. There is no mention by companies of the sectoral or national level innovation systems, suggesting that currently these are top-down policy constructs in UAE and not rooted in bottom-up cluster or SSI creation. table-5.8 in section-5.4 draws attention to the focus on formal knowledge creation and relative weakness of informal knowledge exchanges, especially in UILs.

The overall picture emerging is one of emerging ecosystems in the target technology areas within UAE. Top-down incentives and shared vision encourage interactivity within the ecosystems between businesses, however the deeper levels of interactivity crossing governances have yet to crystallise.

7.6.2 Interactivity at international level between firms and universities

Sennett's (2018) argues that vibrant cities share characteristics such as architecture and space encouraging discourse and ideas swapping. His most powerful idea is that openness to external stimuli and openness to change characterise vibrant cities. This perspective is close to the clustering literature discussed above (cite) i.e. creating institutional thickness by (Amin's term) an *indifference to difference*; active engagement between agents especially around ideas for innovation producing an ever-richer set of relevant meanings, embedded into products, services and relationships. Sennett's ideas are also close to Holland's (2014) notion of emergences arising from complexity and the uncoordinated responses of agents to events and decisions, since both approaches presume discourse (Castells, 1998) is it a social milieu that top researchers and businesspeople want to live in?

The evidence suggests patchy or unsystematic interactivity between the three target sectors and international firms and relevant organisations, especially in knowledge networking. Individual firms have relationships with large companies (especially platform companies, Q-39) and attendance at international conferences (Q-37) are evidence of an ecosystem benefiting from knowledge flow stimuli including the ability to comply with international standards and complementarities (Q-52/53). The R-11 points (section-5.5, R-15) points to the experience gained from international interactions. Examples of this are given by several companies who got ideas for their products from abroad and/or regularly attend international conferences (cite). Overall, however, levels of international sales are low (for high-tech companies from an open economy, section 6.6) and internationalisation of universities limited (30% of staff, lower for students). At a national level bodies respond carefully to international standards, provide a base for international financial institutions, emphasise the need for complementarities and attract investment from large international companies into Masdar city. No company in the three target is part of an international knowledge network developing next generation products and services, though in oil, finance, tourism, property and logistics sectors, as Ahmed and Alfaki (2016) note, UAE companies already have membership.

In summary, at a national level UAE interacts closely with international standards and views attracting investment from international companies as important. At an individual firm and university level, in the three sectors studied, interaction with international trends and events is limited; in informal ("how to") business knowledge flows and knowledge flows related to next generation products.

1.1.6. 7.6.3 Interactivity mediated by the Khalifa Fund

As the principal economic development agency, the KF is acknowledged by 100% of the surveyed firms, the same number are aware of *Vision 2030* and believe it can be achieved (Q-65). Is the KF playing a leadership role in implementing the Vision, in encouraging interactivity in UILs and international knowledge networking? As Mitchell (2009) points out, in an emergent ecosystem, a *new grammar of rational behaviour* is built, celebrating and benefiting from openness and positive responses to high-level knowledge flows: there is a leadership in ideas that spreads throughout the ecosystem. Is this evident in UAE's case?

Evidence from this research suggests a clear disparity between the views of policymakers and firms, represented in the table-5.10 summary of data. R-5 points to a leadership role by the KF (section-5-6), hoping to emulate established international clusters. According to R-15, "*the KF works closely with national organisations and the Khalifa Fund for Enterprise Development* providing, he says, *Excellent guidance and* *consulting for projects"*. R-1 points to the KF trawling universities for commercialisable R&D, echoing R-17's comments that Khalifa University works closely with the Fund, though failing to give successful examples. At a national level the KF, R-3 notes, "*supports the work of the Ministry of Economy's National Council"*. Policymakers thus point to the leadership role of the KF in building advanced technology ecosystems.

The leadership role of building the new target technology ecosystems by the KF seems confined to national and policy level, its impact at firm and individual university level is more limited

7.6.4 Interactivity between levels of scaling

Since the early NIS theorists such as Freeman and Perez (1986), new economic geography (Krugman, 1995; Harvey, 1982 & 1985), complexity theory (Arthur et.al, 1997) and theorisation of autopoietic knowledge flows (Von Krogh and Roos, 1995) the importance of scaling or interaction between levels of (international, national, sectoral, regional) activity has been understood. Table 2.5 summarised these points, including Isenberg's (2011) key point that cultural heritage influences how effectively some ecosystems interact between scales, relative to others. Some of these points feature in Linstone's (2009) multiple perspectives theory, which he summarises as technical, Organisational and personal (TOPs) are used in table 3.2 to classify the 43-factors deduced from literature to constitute an advanced technology ecosystem. Table 3.2 illustrate these factors operating at multiple levels of scaling, represented in the figure 3.2 analytical framework. How well do the UAE's scaling levels interact and in what ways do they strengthen the innovation ecosystems of the target technologies, noting that my unit of analysis is the whole innovation ecosystem? As Kivisaari et al (2013) notes, scaling interactivity is difficult to trace and evidence and is impressionistic.

Vision 2030 is clearly shared by key agents in UAE; it is far from being simply a well-intentioned policy pronouncement: advanced technology using sustained innovation to create a diversified sustainable future is shared widely. Already important innovative ecosystems exist in areas such as air transport, logistics, property, culture, and now tourism attracting important international companies to Dubai Healthcare City and Masdar *City*. Analysis above reveals the challenges in scaling interactivity to build intangible social linkages and knowledge flows, in particular UILs need strengthening. Government encouragement to study abroad (10% of age cohort) and support for university internationalisation (30% of staff) are noted as is support from national Government for city-based incubators and grants to innovative companies. A minority of advanced technology firms participate in international conferences and hope to participate in international knowledge networking.

The KF is not generally recognised as leading interactivity between scaling levels; its successes are at a national level, with growing importance at firm and university level. Leadership of interactivity between scaling levels in UAE rests more with national figures, in particular the President, Khalifa bin Zayed Al Nahyan. This is perhaps unsurprising. Historical examples illustrate the importance in transition periods of visionary leaders encouraging new levels and depths of interactivity. Examples include Lee Kuan Yew in Singapore, Sean Lemas in Ireland, in China Deng Xiaoping, Finland's Mauno Koivisto, and currently *Kersti Kaljulaid* in Estonia. Put simply, leadership is important in building visionary innovation ecosystems; President, Khalifa bin Zayed Al Nahyan's successful promulgation of Vision 2030 for UAE suggests that local-national-international interactivity will continue building UAE's new innovation ecosystems.

To summarise, interactivity between levels of scaling is important in building innovation ecosystems and UAE has successfully shown this ability in oil and non-oil sectors. In the three target sectors studied, interactivity between levels of scaling is patchy, being more successful from national level than at firm or university level. Though Vision 2030 is generally accepted as a guide, the KF is not yet acknowledged as leading its implementation, however the leadership of President, Khalifa bin Zayed Al Nahyan is promissory.

Table 7.8 summarises the findings from this section. Not being ethnographic, this research did not inquire into the line between the public and private in Emirati society. Arab culture, centres the family clearly demarcating the private from the public discouraging the sharing of the private, see Alasuutari (1995) and Bambauer (2013), this includes revealing business information. Western culture encourages open business forums in which innovators share ideas. Examples are CONNECT network events and even television programmes such as Dragon's Den and the Apprentice. One cultural aspect relevant to this research, though not covered in data-gathering are the benefits of openness about business and the potential benefits to the UAE's innovation system of events such as CONNECT. The conclusions chapter will return to this point.

Research finding	Previous research supported	Previous research disputed
Interactivity within UAE stronger than at international level	Geels (2004) Castells and Hall (1994)	Little previous research El-Sokari *et al* (2013)
International interactivity and openness with formal standards etc	Sennett (2018) Holland (2014) Al Nuaimi *et al* (2019)	No previous research Fevolden (2015)
Weak informal international linkages at university and firm level	Winters and Yusuf (2007)	Howells (2006)
KF leadership strongest at national level, weak locally	No previous research, see R-15; El-Sokari *et al.* (2013)	No previous research
Interactivity between scaling patchy, President's leadership critical	No previous research, see section-7.6	No previous research

Table 7.8: Research findings relating to interactivity in UAE's innovation ecosystems

7.7 Meta-innovation trends and UAE's changing innovation ecosystem

By 2030, how will UAE's choice of target technologies have fared? Within life-sciences, software, and non-carbon, which sub-sectors will flourish as commercially successful products, and which become might-have-been? To what extent will UAE's companies feature in global knowledge and value chains? As the discussion on foresight in section-3.1 argues, no definitive answer is possible to these questions. However, alternative futures as Linstone's work (2011) argues can fruitfully be considered and has been deployed to influence long-term innovation strategies, while at a micro level, *picking winners* Phaal et al (2003) argues is a probabilistic rather than scientific activity. This section considers alternative futures and how they might impact on UAE's innovation ecosystems beginning with discussion of ecosystems outside UAE and then focusing on its dynamic capabilities, knowledge flows and a risk analysis, in each case referencing the factors constituting advanced technology ecosystem shown in table-3.2 and the figure-3.1 framework.

7.7.1 *Technology trends and choice of target technologies*

Vision 2030 chooses three sectors on which to focus innovation ecosystem-building: software, life-science and non-carbon technologies. These sectors were not chosen because UAE has a long record of research and absorptive capacity, instead, their future was considered auspicious and UAE strategists believed the economy could successfully innovate and create national champions in these sectors.

Software encompasses programming, Internet security, mobile apps, online platforms, e-commerce, artificial intelligence (AI) and big data diagnostics, including in each case innovative business models. UAE's focus thus far has been on apps and e-commerce using existing US platforms such as Google and Amazon. China's *Sputnik moment* according to Lee (2018) is deep learning technologies moving beyond imitation into radical innovations in big data analytics and associated apps, data-driven services and business models based on superior (to the US) basic and applied research and an innovation ecosystem giving rise to superior products to US and Indian competitors including O2O (online to offline), P2P (peer to peer) disintermediated payment services, all scaled using data sources vastly larger and more extensive than western competitors. China's AI ecosystem Lee argues is already superior to western models: although a newcomer, Lee (2013:212) notes, in emerging technologies *Latecomers are thus no longer latecomers in short-cycle sectors as everybody is a newcomer*. Lee's arguments may prove wrong, but what are the implications for UAE's software innovation ecosystem is they are proven correct? Already Chinese software, Huawei devices and ICT infrastructure dominate south and south-east Asian markets. Could it be that in linking closely to US software companies, UAE has placed a wrong bet?

Ross (2016) argues that care and retail robotics, genetic healthcare, precision agriculture along with AI-based big-data diagnostics bundle the next generation of world-leading products. An accompanying argument is that established centres of absorptive capacity and research capability will create a new geographic division of labour, outside of which those centres without established innovation ecosystems will struggle to join an elite of global cities supporting value-creating products. This exclusion argument is a version of Chang's (2005) *kicking away the ladder* of development using global governances that advantage existing developed countries. The argument also echoes Standing's

(2016) view that though corrupting, historic IP gives advantages to existing companies and countries that emergent ecosystems cannot match. What are the implications for UAE's innovation ecosystems if Ross and or Standing and Chang are correct? It is at least possible that UAE is investing is side-show technologies or ones in which its future role will be (in value attraction terms) marginal.

The point of this limited and tendentious foray into foresight is simply to pose questions; it cannot be assumed that identifying and investing in target technologies that today seem auspicious, produces the global leadership in a high-value sector in ten-years. This will in large part depend on the evolving and dynamic capabilities of the innovators. In none of the three sectors has UAE yet created technology-based globally competitive companies, however, in each sector UAE is home to SMEs and in each sector, universities are undertaking basic and applied research. Evidence needed adding to or disputing what literature?

7.7.2 Dynamic capabilities and the insularity danger

If UAE strategists have chosen wrongly their target technologies or if exploiting these technologies requires unforeseen capabilities, are UAE's innovation ecosystem trapped by insularity or are they aware of changes and able to respond to them? In this sense, the *liability of newness* facing firms could turn into an *advantage of newness* facing institutions. Such agility may also address mismatch (Linstone, 1990) between social attitudes and technological capability. Since innovation ecosystems are multifaceted, they can be in Rubalcaba et al*'s* (2013) terminology opaque, meaning containing unseen logics or predispositions (for example in culture or structures) that makes change difficult. For all these reasons, the capability of ecosystems to change is important, when faced with an altered external environment. To make an analogy with Teece and Pisano's (1994) idea of *dynamic* capabilities at firm level, redeploying assets to new purposes requires learning and marshalling new collective arrangements. This section explores how agile UAE's innovation ecosystem appears to be if faced with external changes of the type discussed above. After examining motors of change, it explores what 'weak signals' of change ability exist and thirdly, how opaque are its innovation ecosystems.

Literature on technology innovation often emphasises single causes; examples might be North's (1990) focus on firm autonomy or Landes (1998) on technology logics. Mokyr (1990) criticising mono-causal explanations suggests alternatively that changing innovation systems requires a wide re-marshalling of social attitudes, rebuilding structures and refocusing research and learning. Archer (2003) too centre stages human agency in institutional change, suggesting that cognitively decided patterns of new behaviour result over time in a new 'hard' and 'soft' context and culture. For example, Pisano (2006) notes how completely different are innovation ecosystems targeting disease and illnesses from a biotechnology than a pharmaceutical perspective. The differences are not only about knowledge domains; they also include such as business models, modalities of research and ethical criteria.

UAE's innovation ecosystems are sufficiently open to adopt the *Connecting Minds, Creating the Future* slogan for the 2020 Expo. Having decided to leapfrog traditional development routes, the country is signalling openness to new ideas, akin to the *highly charged intellectual enterprise* that Todeva and Etzkowitz (2013) say centres on learning. In the case of Japan and Korea, as O'Shea 2005 demonstrates, learning new technologies was accompanied by the double-loop learning (i.e., acting on learning) necessary to implement the new technological expertise based on close UILs. This is not the case in UAE where the TH is shallow and universities prone to autonomy despite Government injunctions for applied research. This suggests that motors of change that have applied in rapidly industrialising countries may not be available in UAE. It is possible that other motors may exist, nevertheless, now it seems fair to conclude that the routes taken by Asian countries to rapidly alter innovation ecosystems are unavailable to UAE.

How sensitive are UAE innovation ecosystems to what Ansoff (1984) termed *weak signals*; the early indications of new product or technology waves potentially disrupting existing target technologies? For Georghiou et al (2008) scanning the technological and market environment is the simple part of this process; more difficult is interpreting meanings and then deciding to shift resources from one technological future to another. According to Christensen's (2003) *Innovator's Solution*, the *Innovator's Dilemma* can be resolved by adopting some of the disruptor's innovations, being permanently innovative and (most importantly) being outcome focused. Here Christensen is recoupling the side of the technology pull/push debate advising firms to be sensitive to both; a tall order, especially if translated from a firm's market segment into a sector's market. Importantly, UAE's international connections in the three target technology sectors are with public agencies (MIT, Fraunhofer) etc, suggesting being removed from the latest market trends. UAE innovators seem able to imitate and act on strong market signals, but not yet on weaker signals from emergent and advanced technologies as the low (3% of total) high-tech start-up rate reveals (GEM, 2017)

Finally, in this sub-section discussing the dynamic capabilities of UAE's innovation ecosystems, how deeply rooted are the innovation systems and to what extent to opaque factors deeply buried in the systems inhibit rapid changes of direction? What makes this question especially difficult is that UAE may be the first Arab middle-income country to join the elite high-income set; and the first oil-rich country to do so. As discussed in section 1.1, oil revenue gives UAE a unique position amongst developing countries and potentially deeply rooted cultural traits that may make it difficult to switch target technologies and associated innovation ecosystem. The *disciplined pluralism* to which Kay (2004) refers when discussing marshalling resources behind innovation seems aptly to describe the 100% acceptance of *Vision 2030* found amongst UAE innovators. As section 1.1 discusses aspects of UAE's labour markets, governances and perverse incentives militate against social acceptance of the *Vision* and may also inhibit any necessary acceptance of a new vision. Rubalcaba et al *'s* (2013) idea of opaque factors inhibiting institutional change. Identifying unknown differences that may result in unforeseen problems in something that might never happen appears a fool's errand.

In summary, if, in the event of external changes, UAE is forced to rethink its target technologies and instead refocus its innovation ecosystems, how capable is it of changing? UAE's motors of change, led by President, Khalifa bin Zayed Al Nahyan has successfully created consensus behind Vision 2030 and arguably could do so again and has the resources to fund such change. However, UILs were central to any change, UAE is not ideally placed. Nor does its international knowledge network connectivity appear positioned to sensitise weak signals heralding new technologies or changes in customer demand a point generally related to the importance of developing stronger international knowledge networking. Finally, it may or may not be the case that opaque factors embedded in UAE sub-cultures and structures inhibit its ability to change target technology innovation ecosystems. In this, UAE may not be different from many of its competitor innovation systems.

7.7.3 *Knowledge flows: the oil of the 21st Century*

How might the nature of knowledge and knowledge domain trends alter and how could this impact on UAE's innovation ecosystems? If knowledge is the oil of the 21st century (meaning most valuable resource), are external trends possible making UAE's innovation ecosystems redundant?

Section 7.5 above notes the importance of reforming UAE's education system, strengthening UILs and joint university/industry applied research in the three target technology sectors. Additionally, as innovation cycles shorted the science-technology gap (Pisano, 2005; Redding, 2005) knowledge will only be relevant as a business asset if accompanied by appropriate venture funding and business models as Lee and Li (2014) argue; this Acworth (2008) and Howells (2006) suggestion is the lesson from Cambridge (UK) and MIT clusters. For R-11 (section 7.4) one answer to this potential problem is to increase the rate of patenting, anticipating that these will buy seats at the table of international knowledge networks.

7.7.4 *Risk and UAE's innovation ecosystem*

A wider range of innovations or events constitute risks to UAE's innovation ecosystems. For example, a major reduction in oil revenues may limit resources for ecosystem investment. This risk could arise from disruption of the Habshan-Fujairah oil pipeline across the Strait of Hormuz; political instability; further falls in oil prices; or income from the Abu Dhabi Investment Authority sovereign wealth fund. The probability and consequences of such risks will undoubtedly be computed by UAE authorities and factored into risk analyses. On the positive side, are the possible benefits from Expo 2020, increasing revenue from tourism and IFDI in Masdar City – all included in the IMF's current 3% pa growth projection.

The results of this discussion on how meta-innovation trends might impact on UAE's innovation ecosystems is summarised in table 7.9 and is necessarily only inconclusively can discuss alternative futures. However, it is again apparent that UAE's case differs significantly from those considered in previous research, particularly in three areas. Firstly, Chang's (2005) idea of the development ladder being kicked away does not seem to readily apply to the resource-rich case of UAE, in which institutions such as the KF, universities and incubators are resourced. Secondly, Gerschenkron's (1966) idea of leapfrogging by securing the most advance technologies is clearly dated in an era where institutions supporting knowledge and its exploitation to build innovation ecosystems is paramount.

Research finding	Previous research supported	Previous research disputed
Difficult picking winners	Phaal *et al* (2003)	No previous research
Alternative foresights possible	Lee (2018) Ross (2016)	No previous research
Development ladder not kicked away for UAE		Chang (2005)
Opaque and unseen logics or predispositions a known unknown	Rubalcaba et al (2013)	Unimportant in systems theory
Criticise monocausal explanations of stunted development are inadequate	Mokyr (1990)	Landes (1998) & North (1990)
Without active agency discussions of institutions are functional and deterministic	Archer (2003)	Deterministic theories, such as SSI and TH.
Leapfrogging now from endogenous knowledge does not purchase of advanced technologies	Johnson (1982) Woo-Cummings (2002)	Gerschenkron (1966)
Innovator's solution difficult: learning to detect weak signals	Ansoff (1984)	Christensen (2003)
Shortening S&T gap also about resource marshalling	Pisano 2005	Lee and Li (2014)

Table 7.9: Research findings relating to meta-trends and UAE innovation ecosystems.

Finally, this research challenges ideas, such as Lee and Li (2014) on shortening the science-technology gap and agrees with Pisano's (2005) original argument that migrating science into technology is inadequate for innovation without sufficient entrepreneurial resources.

7.8 Meta-governances and UAE's changing innovation ecosystem

UAE is a rule-taker in relation to the bodies overseeing governances in the world order (WB, IMF, OECD and UN), though has a strong voice in organisations such as GCC and OPEC: the Washington Consensus that prescribes budget management, tariffs and

IP standards. Although a relatively new national federation UAE has readily complied with the world economic order, from which it has benefited firstly from oil revenue and later standardisation elements in clustering air travel, finance, tourism and property. Is the world economic system at a point of change given the growth of China and India and debate, for example in Sassen (2015) on global governances; and if so, what might be the impact of any change on UAE's innovation ecosystems? Meta-trends are accompanied by changes in meta-governances; these are likely to impact on the innovation ecosystems of a small open economy such as UAE and are represented by arrows [7] and [8] in figure 3.1.

Some previous research suggests that meta- or global governances could constrain UAE's innovation capacity. For example, Ulrichsen (2011) argument that social chapters in international treaties could constrain UAE development has proven unjustified. Similarly, Buckley and Hanieh (2014) argument that UAE's growth could suffer from over-exposure to high-value residential and commercial property values, looks misplaced given that the post-2008 shock to western economies far out-weighted that on the UAE. Sudjic's (2005) warning of an edifice complex (dictators wasting resources on vanity projects) appears irrelevant to UAE.

Inward migration is a positive benefit to UAE posing none of the issues poses in developed economies since there is no question of migrants integrating (citizenship) or gaining leave to remain (beyond contractual arrangements). Half of the surveyed companies point to staff shortages a figure that would rise significantly if skilled migrant labour was not available, since (Q-50) 90% of interviewed companies employ migrant staff. For some specialist technical roles Khodr and Reiche (2012) found firms generally have difficulties attracting staff from abroad. Any alteration to international governances reducing labour mobility would substantially affect UAE. Similarly, since UAE supply (60% of products) and sales (10 to 20% product average) by innovative companies are international and changes to tariffs or friction would have an adverse effect.

Industrialisation late-comers have little choice but to accept the meta-governances already set in place (and suiting) incumbents. In UAE's case, existing global governances appear to suit the innovative ecosystems, which enable rather than constrain development. The danger of UAE is radical change in meta-governances. The risk therefore is disruption to these arrangements because of external shocks. These points are summarised in table 7.10

Research finding	Previous research supported	Previous research disputed
Meta-governances enable rather than constraint UAE's innovation ecosystems.	No previous research on enabling role of UAE meta-governances	Ulrichsen (2011) Buckley and Hanieh (2014) Sudjic's (2005)
Major changes to meta-governances could inhibit innovation ecosystems.	Sassen (2015)	No previous research

Table 7.10: Research findings relating to meta-governances and UAE innovation ecosystems

Conclusion

Table 7.11 brings together the results of this research in relation to previous research, indicated coherence or dispute with previous work. Thirty-nine points are noted, however, what is the 'big picture' new contribution of this research?

Research finding	Previous research supported	Previous research disputed
Emirati innovators in advanced sectors		
1. *Articulated spirit* of Emirati entrepreneurship is strong in advanced sectors often combining role of innovator with that of entrepreneur.	Phan (2004); Audretsch (2014); Utterback *et al* (2019); Cunningham *et al* (2019)	Hameed *et al* (2016) Dubai SME (2013)
2. Young Emirati women are actively starting up firms in advanced sectors: this factor is missed or understated in previous research.	Ergul and McCrohan (2008); Tlaiss (2014); Marmenout *et al* (2014) Dutot *et al* (2015)	Davidson (2011) Majumdar & Varadarajan (2012); Al Khayyal (2020)
Emirati innovator legitimacy		
3. Innovation ecosystems often combine roles of innovators and entrepreneurs.	Mitchell (2009)	Shane (2004) Sarasvathy *et al* (2009)
4. Ecosystems rely on firm legitimacy, which in emerging economies takes forms different from those in developed economies.	Arthur (2015)	Mason and Brown (2014); Stam (2015); Aksoy and Beuadry (2020)
5. Liability of newness offers greater opportunities for new firms in emerging innovation ecosystems than new firms in mature ecosystems.	Holland (2015); Haegeman *et al* (2012); Audretsch and Belitski (2021)	Stinchcombe (1965)
Emirati innovator marshalling of resources		

6. Diversification an 'internal' goal for sustainable innovation ecosystem. 'external' goal is networking with international companies on new product development	Vision 2030; Audretsch and Belitski (2021)	Sachs and Warner (2001)
7. Stages in traditional development theory can be leapfrogged by resource-rich emergent innovation systems; apparent high entry ticket cost of new Emirati firms into international knowledge networks	Johnson (1985); Jones *et al* (2020); (Zhang *et al* 2019); Oliver *et al* (2020); Meng *et al* (2020)	North (1990); Cai and Cui (2015)
8. Emergent institutions for marshalling resources differ from mature institutional arrangements: different logics apply, not captured by Etzkowitz	Woo-Cummings (1992); Van Geenhuizen (2019)	Etzkowitz (1983)
Research findings relating to knowledge flows		
9. Schooling good but needs reform to achieve best international standards.	See R-3	Lapidus 2012
10. Old (rote) pedagogy and low but improving entrepreneurship education.	Hameed et al (2016)	Alkhateeb (2014); Hayter (2015)
11. Universities internationalizing students, less so in research (except oil and medicine)	Kirk and Napier (2009)	No previous research
12. University traditional teaching.	Sowmya *et al* (2010)	Masri *et al* (2010)
13. Low level of university-industry links	Jabeen *et al* (2016); Leydesdorff and Ivanova, 2020; Baglieri *et al* (2019)	No previous research
14. Major science and technology gaps in target sectors, little evidence of gaps closing	Melley (2010); Jones *et al* (2020); Abdurakhmanova *et al* (2020)	No previous research, Bich (2021) comments
15. High level of R&D spending contrary to Howells' findings.	Howell (2006); Toan (2021); Gan *et al* (2020); Schwab (2013)	Howells and Wood (1993); Guerrero and Urbano 2012
16. Focus on formal knowledge flows not applied/commercial.	Howell (2006)	No previous research on balance of tacit/formal knowledge generation in UAE start-ups; Guerrero and Urbano 2012
17. Little membership of international innovation knowledge networks (in target technologies) due to lack of R&D capability	Howells and Wood (1993); Yang *et al* (2021); Oliver *et al* (2020)	Howell (2006)
Research findings relating to UAE institutions		
18. Thickness of institutions important especially trust: UAE continues institution-building	Amin (1994); Haegeman (2012); Fevolden (2015)	Sikdar (2011)
19. Limited learning from large companies (partners or IFDIs).	Howells (2006); Mazzucato (2013)	Winters and Yusuf (2007)
20. UAE a special case of institutions based on developing economy/society, yet already high incomes.	Zhang (2019); Chamberlain and Kalaitwi (2020)	Ahmed and Alfaki (2016)
21. Human capital quality important, yet low take-up of vocational education in target technology ecosystems.	Fasano and Iqbal (2003) Hertog (2010); El-Sokari *et al.* (2020)	Al Nuaimi *et al* (2019)
22. Compliance with international standards e.g. IP law: internationally trusted legal system	Davidson (2011)	Skok and Tahir (2010

23. High percentage of advanced technology innovators are women – new finding not found in previous research.	Ergul and McCrohan (2008)	Majumdar and Varadarajan (2012)
Research findings relating to interactivity in UAE's innovation ecosystems		
24. Interactivity within UAE stronger than at international level.	Geels (2004) Castells and Hall (1994)	No previous research; El-Sokari *et al* (2013)
25. International interactivity and openness with formal standards etc.	Sennett (2018) Holland (2014) Al Nuaimi *et al* (2019)	No previous research Fevolden (2015)
26. Weak informal international linkages at university and firm level.	Winters and Yusuf (2007)	Howells (2006)
27. KF leadership strongest at national level, less strong internationally	No previous research, see R-15; El-Sokari *et al.* (2013)	No previous research
28. Interactivity between scaling patchy, President's leadership critical.	No previous research, see section-7.6	No previous research
Research findings relating to meta-trends and UAE innovation ecosystems		
29. Difficult picking winners.	Phaal *et al* (2003)	No previous research
30. Alternative foresights possible.	Lee (2018) Ross (2016)	No previous research
31. Development ladder not *kicked away* for UAE: clear pathway to joining international elite, sustainably innovative economies		Chang (2005)
32. Opaque and unseen logics or predispositions: important to identify powerful logics	Rubalcaba *et al* (2013)	Unimportant in systems theory
33. Criticise monocausal explanations of stunted development as inadequate.	Mokyr (1990)	Landes (1998 North (1990)
34. Without active agency discussions of institutions can prove functional and deterministic.	Archer (2003)	Deterministic theories, such as SSI and TH.
35. Leapfrogging now from endogenous knowledge, not from purchase of advanced technologies.	Johnson (1982) Woo-Cummings (2002)	Gerschenkron (1966)
36. Innovator's solution difficult: learning to detect weak signals.	Ansoff (1984)	Christensen (2003)
37. Shortening S&T gap also about resource marshalling.	Pisano 2005	Lee and Li (2014)
Research findings relating to meta-governances and UAE innovation ecosystems		
38. Meta-governances enable rather than constraint UAE's innovation ecosystems.	No previous research on enabling role of UAE meta-governances	Ulrichsen (2011) Buckley and Hanieh (2014) Sudjic's (2005)
39. Major changes to meta-governances could inhibit innovation ecosystems.	Sassen (2015)	No previous research

Table 7.11: Summary of research findings related to previous research

These research findings are discussed further as theoretical contributions in the following conclusions chapter. Notably new are the findings (2) on the role of Emirati women entrepreneurs, (4) firm legitimacy in developing economies, (7) UAE's ability to benefit from the liability of newness, (13) the low level of UILs and (17 and 26) importance of international product development networks, (19) limited learning from IFDI, and (35) signs of endogenous knowledge creation.

Table 7.12 reproduces the gaps in the literature identified in the literature review indicating in each case the contribution of this research.

	Gaps in literature	Contribution
1	Insufficient empirical research on UAE entrepreneurship in particular issues of young entrepreneurs and university spinouts and associated questions of IP, risk capital, exit routes	• Significant empirical data added
2	No study and analysis of Khalifa Fund and its contribution to Vision 2030	• Study centred on KF now complete
3	No systematic analysis (Al-Naqeeb) of UAE's strategy for achieving knowledge-based economy status	• Systematic analysis of UAE strategy
4	No analytical framework specifically designed for economies with UAE characteristics (high-investment resources, mid-range industrial structure) noting Linstone's (1996) mismatch theory i.e. how social institutions and technological capability align; additionally, Skok and Tahir's (2010) suggested gap in research on Gulf cultures and context in building a modern economy.	• New analytical framework (figure-3.2) specifically for UAE context
5	No systematic analysis of the difficulty in applying Etzkowitz's (2008) Triple Helix to a rapidly developing economy such as UAE	• Analysis complete
6	As section 3.2 points out, MPT has yet to be applied to a context of a rich developing economy such as UAE, with leapfrogging capability, posing issues for what scaling and TOPs will be relevant and how these might differ from convention (poorer) developing economies. Section 2.2 above poses similar issues in relation to economic development and economic transition theory.	• Contribution building on Linstone's work
7	Agency and physical ecosystem theories are sometimes conflated, resulting in determinism. My work will clearly feature active agency as an essential characteristic of UAE's innovation ecosystem	• Active agency centred in analysis of UAE innovation ecosystems
8	Section 2.1 argues that innovation and entrepreneurship inseparably link implying that envisioning ecosystems as simply creating technological novelty is inadequate; instead, an E&I ecosystem necessarily contains agents supporting entrepreneurial activities.	• Case made for closer integration of innovation and entrepreneurship
9	Section 2.3 highlights the importance of focusing on new learning process instead of the management of exiting knowledge making active learning and risk-taking agency an essential part of an E&I ecosystem and calling attention to UILs, education standards and the absorptive capacity of staff all of which connect with Government interventions. The gap here is conceptualising ecosystems sufficiently broadly to include these factors.	• Learning centre-staged in analysis of UAE innovation ecosystems
10	Noting the disincentivising effect on entrepreneurship or resource richness, section 2.3 suggests this is a gap needing further research.	• Researched and discussed
11	Section 2.3 argues that shortening the science-technology gap critically involves understanding governance clashes with the UIL triangle, issues that previous research has neglected in developing economies.	• Governance issues researched and discussed
12	The profile and motivation of UAE entrepreneurs is an under-researched area (section 2.3)	• New research on UAE innovators
13	UAE's sectoral innovation systems (perhaps apart from oil) are under-research as section 2.1 illustrates, in particular building SSIs in knowledge-based sectors that effectively link with international knowledge networks.	• Three UAE innovation ecosystems researched

Table 7.12: Gaps identified in literature from introduction (table-1.3) and responses

The overall contribution of the reseach is wider than disputing previous research or filling gaps in the literature relating as it does to significant research questions, empirical contribution and suggestions for practical policy. It is to these the thesis now turns in a conclusions chapter.

CHAPTER8: CONCLUSIONS AND CONTRIBUTION

Introduction

The ‘big picture’ from this research is in two parts. Firstly, and positively, UAE’s innovation ecosystems in the three targeted technologies (software, non-carbon and life-sciences) are modern, well-resourced and reference international standards. They are the product of a developing economy endowed with significant resource revenue and a clear diversification strategy – *Vision 2030* – which is generally accepted as a shared destiny and used to guide policy implementation. However, there are important obstacles the innovation ecosystems need to overcome if the goal of a sustainable innovation-based future is to be achieve. These obstacles revolve around learning and the use of knowledge and relate to the quality of school education, the quality of and balance between applied research in universities, entrepreneurship education and pedagogies supporting creativity and an overall increase in absorptive capacity and research capability sufficient to buy entry tickets into international product knowledge networks.

Chapter-1 (section-1.3) set four reserch objectives, figure-8.1 indicates how these objectives have been met.

8.1 Theoretical contributions

From the literature review, table 2.4 gathered thirteen gaps that this research aimed to address, with table 7.12 showing in each case how these gaps have been responded to. This section gathers these responses under three headings as the theoretical contributions of this research: (a) developing Linstone’s ideas into a new theoretical framework with which to analysie innovation ecosystems; (b) the nature of innovation ecosystems in resource-rich developing economies; and (c) the importance of intangibles such as learning and knowledge-flows for successful innovation ecosystems.

8.1.1 Developing Linstone into a new theoretical framework

Section 1.2 discussed Linston’s multiple perspectives theory and TOP toolkit, noting his call for the use of complexity theory (2009) and his suggested use of ecosystems as a conceptual improvement on systems theory (1996), in particular allowing multiple perspectives arising from scaling as various appropiate levels as influencing innovations.

Research Objectives	Outcome of objectives
<u>Objective 1</u>: Review the relevant innovation systems literature and develop a conceptual model that helps mapping of the key factors constituting knowledge-based innovation ecosystems.	• Top journals referenced up to 2021 • Key factors (figure-3.2) derived from literature • Framework-1 encapsulates previous research, framework-2 contribution from this research • Frameworks and research questions structure the entire research project
<u>Objective 2:</u> Theorizing if found, a knowledge-based innovation ecosystem and to develop a systemic understanding of its complexity.	• Chapter-3 theorises an innovation ecosystem for a wealthy developing economy with emergent institutions encapsulated in figure-3.2 which structures data gathering, the analytical results of which are in the figure-8.1 re-conceptualised framework
<u>Objective 3:</u> Demonstrating the epistemological instance for constructive grounded theory and justifying the major methodological choices and their relevance to the research aim and questions.	• Section-4.3 explains and justifies the choice of Charmaz's (2019) constructed grounded theory • Chapter-4 identifies, discusses and justifies all of the major methodological choices in this research and why they are appropriate to the research question, in particular the choice of exploratory and mainly qualitative research for an under-explored research field.
<u>Objective 4:</u> To offer a deep understanding of the cultural and contextual factors that enhances the innovation ecosystem in the UAE.	• Context and culture are referenced throughout the research drawing on Ilyenkov's (2020) ontology, Vygotsky's (1934) social learning and epistemic approach. • Evidence of context and culture influencing innovation practice is presented in chapters 5 (qualitative) and 6 (quantitative) and reintegrated into analysis (chapter-7) referencing previous literature. • Changing context and culture in UAE is particularly evidenced in the education systems and the rise of women entrepreneurs.

Figure-8.1: Meeting the research objectives

Unlike systems theory and other approaches, (such as Etzkowitz's 2008 triple helix) Linstone is wary of 'logics' modelling as introducing determinism and instead urges researchers to ground analyses in particular technologies and particular contexts and cultures. This research uses Linstone's insights and the later work of Fevolden (2015), Galati *et al* (2016) and Strasser (2018) to build a new framework for analysing innovation ecosystems appropriate to the UAE situation i.e. rapidly emerging innovation ecosystems in an economy endowed with significant revenues from natural resources.

- Discussing the complexity theory approach in section 2.1, for example (Holland, 2014) identifies three characteristics especially important for investigating innovation ecosystem: emergences, absence of central coordination and active agent responses to events and the decisions of other agents. Together these avoid the potential determinism found in some systems theories.

- The same section also discusses ecosystems approaches; table 2.1 cites the important concepts from ecosystems research for use in analysing innovation ecosystems and table-2.3 lists factors the presence of which will importantly influence the success of innovation ecosystems.
- Criticising some NIS and SSI research for failing to effective switch between levels of scaling referencing Von Krogh and Roos' (1995) autopoietic approach, Table-2.5 presents five levels of scaling (from international, national, sector, firm and KF) appropriate for use in analysing innovation ecosystems in the UAE's three target technologies i.e. software, life-sciences and non-carbon technologies. Linstone's (2009) emphasis on interactivity between levels of scaling and Galati *et al's* (2016) findings on timescales importantly illustrate active agents operating at multiple levels, in multiple timeframes and in grounded innovation ecosystems will take decisions and act in response to events and decisions in levels of scaling other than the one they primarily occupy.

Chapters 2 and 3 of the Thesis discussed this literature, identifying gaps in the literature (table 2.4) and concepts then used in Chapter 3 which constructs a new framework for analysing innovation ecosystems. This is done in table 3.2 by gathering the factors from the literature appearing to influence the nature and operation of innovation ecosystems, classified using Linstone's (2009) TOP criteria. These forty-three factors are justified in section 3.2.2 and gathered in table-3.4, then distilled into thematic groups: these are (a) innovator/ entrepreneur active agency; (b) legitimacy; (c) marshalled resources; and (d) knowledge flows. The choice of themes is justified as being critical to the success of innovation ecosystems. Figure 3.2 suggests how the forty-three factors might be distributed between the selected levels of scaling. Figure 3.1 represents a major theoretical contribution of this research – a new framework with which to analyse innovation ecosystems in rapidly developing economies, endowed with resources. In the framework transition from old or existing ecosystems to new (target technology) ecosystems occurs because of interactivity within and between the eight themes shown and discussed in section 3.3, following which section 3.3.1 indicates how the framework will be used – principally by grounding analysis in empirics and observed actions/ decisions i.e. by tracking the processes of change in the emergent innovation ecosystem, examples of which are given in table 3.5. These forty-three factors, embedded in the figure 3.1 framework then guide this research: the data gathered, its presentation, its analysis and (Chapter7) reintegration with previous research literature. Section-8.4 below reconsiders the framework themes and relationships in the light of the research findings and following Charmaz (2006) amends the framework as a final research contribution.

8.1.2 Nature of innovation ecosystem in a high-income, developing economy

To the author's knowledge, there is no previous research using an ecosystem framework analysing innovation in UAE. In part this may be because the ecosystem is processual; it explores in a particular context and culture why and how (in this case) innovations occur, their shape and relationship with existing and future technologies. Using innovation ecosystem as unit of analysis therefore is best done with rich prior knowledge of meanings and interpretations in the target context.

Traditional development models follow a route from primary, to low-value and then high-value manufacturing and alter service industries (North 1990). Assumptions embedded in this approach are shown as not universal by this research. Stinchcombe's (1965) *liability of newness* in a high-income innovation ecosystem development context no longer centres on attracting investment and instead is focused on how intellectual assets are valued, the value of future income streams and evaluation of capability to participate in international knowledge networks. It may be, as section 5.7 argues there is an advantage of newness in the form of less technological insularity. Though developing rapidly and lacking some of the institutional arrangements assumed in Etzkowitz's (2008) triple helix approach, a more fundamental deficit in UAE-type innovation ecosystem development are invisible assets such as trust in information flows. For these reasons the 'logics' assumed by Etzkowitz's (2008) do not apply.

If there is a potential downside to innovation in a resource-rich context it is perhaps the demotivation to take risk and work hard when softer high-income employment is available (Frankel 2010). Several studies suggest that young Emiratis are de-motivated as innovators in this way: Goby and Erogul (2011); Al-Waqfi and Forstenlechner

(2012); and Erogul (2014). Where this the case, it may help explain the space left for women entrepreneurs (Ergul and McCrohan 2008): this research survey found a third of advanced technology innovators are women, who Majumdar and Varadarajan (2012) argue are motivated by independence. Also, as secton-2.3 notes, the SME start-up rate in UAE is like that of advanced countries such as Norway and though only 3% using advanced technologies sounds low, as a percentage of the 200,000 stock 3% is a high number; another example of how UAE's pathway to innovation ecosystem differs from the traditional model. Perhaps the most important differentiation from the traditional development model for creating innovation ecosystems is in leapfrogging.

Gerschenkron's (1966) idea of latecomers out-competing established innovation systems by purchasing the most advanced technology and not being encumbered by repaying the cost of older technologies, does not apply in the UAE case, since the advanced technology products and processes are emergent and therefore guarded as giving competitive advantage. The late entrant, as Utterback *et al* (2019) notes, is able to identify and fill gaps in existing ecosystems, shown in the UAE success in solar energies. UAE innovators know that to leapfrog incumbents they must generate new knowledge or new combinations (Pisano 2006). A final point made in this research on the how a high-income entrant to innovation ecosystems differs from traditional models, challenges Chang's (2005) argument that monopoly power over IP and control of platforms prevents late entrants joining the elite group of innovators, albeit with only a limited number of SMEs being technological-advanced Hameed *et al* (2016) suggest 3%. The entrant high-income ecosystem is capable of investing in R&D (including transferring-in researchers) and overcoming barriers to building innovation ecosystems in advanced areas, as the existing ecosystems in UAE (finance, property, air-travel, culture) illustrate. In summary, this research challenges a range of assumptions embedded in traditional understanding of innovation ecosystem development, *in the case of a high-income late entrant*; these challenges are less applicable in low-income cases.

8.1.3 Intangibles: the importance of learning and knowledge use

Amin's (1994) idea of institutional thickness and Storper's (1992) untraded inter-dependencies for cluster-building relate to physical infrastructure and trust build over long-term patterns of inter-trading. More recently, Audretsch's (2004) work on spillovers from large companies in biotechnology suggest the importance of learning from large companies and as Abdurakhmanova *et al* (2020) notes, aligning university research with company new product development. This research supports Winters and Yusuf (2007) argument on the importance of such learning in innovation ecosystem development; section 7.6 noting that relationships with large companies are not resulting in significant knowledge flows into the innovation ecosystems, which may change as Masdar City evolves. Linstone (2010) noted that without mutual learning mismatches can occur between the goals of innovators and what they are able to deliver.

A key finding of this research is that without the absorptive capacity and R&D ability to contribute to international knowledge networks, nascent innovation ecosystems are excluded: Leydesdorff and Ivanova's (2020) synergy indicator. Whilst like Howell's (2006) findings in relation to knowledge networks involving large companies, this conclusion relates to the learning capacity of SMEs and draws conclusions for wider aspects of innovation ecosystem emergence. The research suggests the UAE's school and universities' education system's pedagogy needs urgent reform to feature entrepreneurship education, creativity, encourage S&T subjects and in the case of universities support more applied research and closer linkages and exchanges with business, perhaps by applying Jones *et al* (2020) evaluation framework. In addition, universities are insufficiently internationalised and firms in university incubators gain insufficient tacit ("how to") knowledge from interactions with business, in part because the incubators are led by academics rather than experienced businesspersons. In parts these points agree with Lapidus (2012) who also connects innovation rates with creativity and business linkages in education; Cunningham *et al's* (2019) entrepreneurial universities. This research, however, is drawing wider connections including the current inability of UAE's emergent innovation ecosystems to participate in international knowledge networking. Low levels of learning and knowledge capability also inhibit innovation ecosystem agents from discerning Ansoff's (1984) weak signals, necessary Christensen (2003) suggests avoiding disruption, and we might add insularity of the wider ecosystem.

8.2 Empirical contribution

There is surprisingly little research into UAE or Arab country innovation, with Skok and Tahir (2010) calling for more research; a gap this research helps to fill. The conclusion of chapter 5 summarises the results from the survey and interviews conducted for this research and figure 6.35 summarises the empirical results of this research in relation to the forty-three factors constituting an innovation ecosystem derived earlier from the literature review and embedded into the framework shown in figure 3.1. Avoiding repetition, this section selects the standout items making empirical contributions not found in previous research.

While previous research such as Majumdar and Varadarajan (2012) and Al Khayyal (2020) comment on the motivation of Arab women innovators most researchers (e.g. Al-Waqfi and Forstenlechner (2012) pay little attention to women. This is despite Dutot *et al's* (2015) finding that digital innovation suits the culture of Arab women. This research finds a social dividend resulting from the high enrolment of women in higher education (60% of enrolments), and noting the 40% labour market participation rate, finds (section 6.1) that a third of innovators in innovation ecosystem are women.

- One of the remarkable indicators of modernisation in UAE is the high participation rate of young women in higher education (60%) and intention to start their own business (80%); 40% of Emirati women now work. Women are almost a third of the innovators survey. These are represented in non-carbon (30%), life-science (12%) and software (50%) reflecting the rising contributions of women in UAE mentioned in sections 1.1 and 2.3; the survey finds women significantly represented amongst Emirati innovators, supporting Tlais's (2014) view that cultural barriers are reducing and disputing the findings of Al Khayyal (2020).
- One aspect of the Asian development state model is a shared passion amongst the population to create a successful national identity; this is translated into a preparedness to forego current consumption to fund investment. Both the survey (Q-65) and interviews (section-5.6) show a remarkable degree of social cohesion around UAE's *Vision 2030*. Not a single person demurred from accepting the *Vision* or expressing belief that it can be achieved. Similarly, the leadership of President, Khalifa bin Zayed Al Nahyan seems to be widely accepted. The importance of this

finding is to suggest that in the event of UAE's ecosystem-building hitting trouble (section-7.7 considered some of these risks) there is sufficient cohesion and leadership to overcome problems.

- Literature on development pathways, such as Chang (2005) often criticises the existing world order of institutions influencing innovative ecosystems as disadvantaging emergent ecosystems. Evidence (for example, section 5.5 and R-15 shows agents in UAE's innovation ecosystems accepting international standards, governance arrangements and generally complying with accepted international ways of working). In part this is learned from the practice of UAE's existing successful innovation ecosystems. Far from supporting Chang's case, UAE innovators, as section-7.8 notes, revel in the opportunities for complementarities and hope of joining international knowledge networks, perhaps again revealing the different perspective from emergent innovation ecosystems based in a high-income context. This research then disputes Chang's theory and the empirical findings of Hameed *et al* (2016), supporting instead Utterback *et al* (2019) and Cunningham *et al's* (2019) view that pathways exist for UAE to join the elite group of innovation-sustainable economies.
- UAE is internationalising its university system, allowing western annexes and investing significantly in imported staff (30%) and models such as university-attached incubators. UAE spending on R&D is high, disputing Howells and Wood's (1993) finding that emergent innovation ecosystems have low spending. This research supports Jabeen *et al's* (2016) finding that UAE universities have low UILs and Sowmya et al 2010) and Hameed *et al's* (2016) finding that pedagogies are mismatched with goals featuring creativity. These links are especially important in sectors such as life-sciences where *sticky knowledge* (Audretsch 2014) can be critical and takes time to absorb. In UAE's case, given the presence of inward investing companies and existing successful clusters, there is less justification for weak UILs than might be the case for emergent innovation ecosystems in some developing countries. Only five of twenty-seven companies survey, have deep knowledge links with universities, yet interviewees are sanguine that universities are performing a supportive role to innovation ecosystems (section 7.6). Shallow university internationalisation and weak UILs are linked in that the success in applied research and commercialisation of international universities relies upon UILs. Staff and structure imitation miss the essence of how partner universities

work in practice. This has implications for the quality of human capital being developed and success rates from incubators. Al Nuaimi *et al* (2019) is wrong to suggest that human capital in UAE is under-developed, however, there remains a gap between UAE and elite innovator economies.

- No previous research investigated knowledge flows in UAE's innovation ecosystem. This research supports the findings on the importance of knowledge flows by Oliver *et al* (2020) and Yang *et al* (2021). Apart from acting as a general paradigm, there appears little spill over of knowledge from established innovation ecosystems in other sectors no interviewee mentioned any such learning. A central finding of this research is the absence of UAE firm involvement in international product knowledge networks or knowledge spills from IFDIs: there is little knowledge flow from large companies into the innovation ecosystems essential to shortening the gap between new scientific development and new technological products (Lee and Li 2014). Knowledge flows are discernible at a personal level, such as innovators who saw opportunities while abroad or intuited there was a market gap. National policy Officials emphasise formal knowledge flows from hiring international staff and preparing patents and not "how to" informal knowledge from either foreign or domestic businesses into the emerging innovation ecosystems. Innovators express a desire to participate in knowledge networks, but none do and only five work on knowledge development with Emirati universities. All this suggests that in the innovation ecosystem with three target technologies there is an absence of absorptive capacity and research capability to contribute to ground-breaking product development. If so, this is a serious conclusion. Important to map capabilities, and guide universities and companies to fill gaps, a conclusion supporting Al Nuaimi *et al's* (2019) findings.
- The point of innovation systems Pisano (2006) argues, is to more efficiently narrow the gap between science and technology. Levers for doing so featuring in this research are the 8 themes in figure 3.1. These include specific actions such as resource marshalling using incubator structures, which are one aspect of UILs, others being joint applied research and exchanges between universities and business (Al Nuaimi *et al* (2019). These include work-based learning, freaquent use of talks and case studies in learning, business-focused research projects (action learning) and entrepreneurship education. Versions of this perspective are found in general

economics literature beginning with Solow (1956) and more recently Gibbons *et al* (1994), Lecuyer (2006) and Micklethwait and Wooldridge (2014). The challenge of UILs is operating with hybrid governances (Dahlstrand and Klofsten 2003) combining academic and business ways of working, led by business. There is little evidence of effective UILs in UAE as evidence from companies (figure-6.31), academics (section-5.4) and policymakers (R-1; R-12; R-17) reveals. This key finding has important implications for future policy. Without the commercialisation of research at the current level of scientific knowledge, the science-technology gap in UAE will not be narrowed.

- Associated with the previous point, the research finds that no UAE firms in the target sectors are connecting the innovation ecosystem with international knowledge networks developing next generation product (see figures-6.31 and 6.27), though 64% participate in general (i.e. not product development) networks. This supports the findings of Al Nuaimi *et al* (2019) and disputes the more sanguine results of El-Sokari *et al* (2013).
- Finally, evidence suggests innovators and policymakers acknowledge the KF (section-5.6; Q-57), 71% of companies make use of its services (Q-59), somewhat disputing the findings of El-Sokari *et al* (2013), though their main focus in on the national level work of KF. Is the KF playing a leadership role in constructing the innovation ecosystems? Policymakers (R-2; R-15) see KF as a 'connector' and provider of services. Nobody points to the KF as guiding the implementation of Vision 2030. For example, R-20 points to UIL gaps and weak, but does not offer an improvement agenda.

The eight points above constitute new and significant empirical findings from this research, some challenging and some supporting previous research.

8.3 Answering Research questions

Section 1.6 framed the problem into which this research inquires as one of building innovation ecosystems and lack of previous research leaving significant gaps in research literature, which section 1.5 unpacked. Section 1.4 posed the following research questions, summarising the flow of data gathering and analysis to answer the questions in table 1.4 and identifying clear research aims and objectives in section 1.3. This section answers these questions.

RQ: To what extent does Linstone's Multiple Perspective Theory help understand the foundations of the innovation ecosystem in the UAE?

Sub-RQ1: What are the key factors of the knowledge-based innovation ecosystem in the UAE?

Sub-RQ2: How policymakers and entrepreneurs perceive that the challenges facing the innovation ecosystem in the UAE?

Sub-RQ2: How the knowledge-based innovation ecosystem operates at the meta level in the UAE?

8.3.1 Main Research Question:

"To what extent does Linstone's Multiple Perspective Theory help understand the foundations of the innovation ecosystem in the UAE?"

Linstone's approach to understanding technology innovation grew out of an epistemological approach (1975; 2010) synthesising diverse areas of grounded expertise. To this, since (1988) he added the multiple perspectives, approach including multiple scaling (2009) to create a synthetic approach like Dewey's pragmatic technology (Hickman1992). In this later work Linstone (2011) proposed including ideas from ecosystem, complexity, and learning theory in technology innovation analysis. This research makes this synthesis by building on Linstone's work and as Chapter 3 makes clear, adding concepts and relationships from complexity (Holland 2014), ecosystems (Holland 2015) and learning theory (Vygotsky 1934) to create the analytical framework shown in figure 3.1 and emphasised in Fevolden (2015). This framework embeds a multiple perspective approach and multiple levels of scaling and takes forty-three factors influencing innovation ecosystems, themed into the eight themes shown in the figure. Specifically, the figure includes the high levels of ecosystem investment found in UAE's case, as a high-income country, which would be differently contrived for most developing country ecosystem, where investment will be lower. The framework is processual, tracking change in complex ecosystems from 'old' to 'new' innovation ecosystems.

This research centres on the UAE's *Vision 2030* (2008), which aims for the *Emirates to take its place among the most successful economies of the world by 2030* and the three target technologies chosen: software, life-sciences and non-carbon. Having gathered data from a survey of twenty-seven companies in the three sectors and twenty-one Government Officials and Incubation Managers supporting the innovation ecosystems (Chapters 5 and 6), this research is able narrate UAE's innovation ecosystem story, filling as indicated in table 7.12 gaps in the research literature.

8.3.2 Sub-Research Question 1

"What are the key factors of the knowledge-based innovation ecosystem in the UAE?"

UAE launched its *Vision* in 2008. In several sectors as Al-Raisi, Amin and Tahir (2011) note, such as property, finance, culture and oil and gas) it already has internationally successful innovative ecosystems. Overall UAE enjoys a 4.5% GDP annual growth rate and in large measure is avoiding what Beblawi (1990) calls a *rentier mentality* or Auty (1997, 2001) the *curse of natural resources*, as is investing heavily in diversification and the three target innovation ecosystems as a long-term strategy. It is worth noting how long the timespan has been for other countries to make this journey. Japan began industrialisation in 1865 take perhaps 70 years to become innovative (Galati *et al* 2016). Korea, even with substantial US technology transfer and assistance took twenty years; a similar time UAE proposes without the same degree of US assistance. Already, UAE has a competitive TEA rate (IMF 2016), including 3% of start-ups using advanced technologies, a major achievement for a small country.

In 2008, UAE had little absorptive capacity and research capability in software, non-carbon and especially life-science technologies. Meta-trends indicated and still indicate (7 in figure 3.2) expansion of products and markets in these areas. Building endogenous research capabilities and improved education, including support for international study, UAE's social trends (8) favourably supported the 2030 Vision. Operating them at the multiple scaling shown in (5) and with significant interactivity within ecosystems, the forty-three factors, thematised into (1), (2), (3) and (4) in figure 3.1 have strengthened innovation ecosystems in the target technologies, into a discernible and (qualified) success. Referencing table 7-11 showing metrics of change for each of the forty-three factors, this research shows for example in (1) educated innovators, including one-third women, trawling for ideas in advanced technologies and successfully launching companies using incubation facilities, attracting external investment and trading internationally. Challenges however remain, applied and join university research would give rise to more commercialisable ideas, business-led incubation and stronger UILs would shorten innovation cycles. Firm legitimacy (2) poses difficulties for firms in developing innovation ecosystems, however, evidence shows firms trading internationally, registering patents, learning from customers and partners. A major gap in legitimacy is lack of learning from large companies and relatively low international sales. Although Cai and Cui (2015) suggest the importance of these relations may be exaggerated, this research concludes with Van Geenhuizen (2019) that they remain essential. Firms in the innovation ecosystems are found (3) able to marshal resources for start-up and early growth, though difficulties getting working capital from banks may be slowing growth. The legal, tax, logistics and IP arrangements in UAE support the innovation ecosystems, enabling an overall leapfrogging of ecosystem beyond tradition development pathways. Knowledge flows (4) in UAE appear superior to many developing economies (schooling, universities, international links); these feed into the innovation ecosystems and firm start-up and development. However, education and universities need significant reform, particular in UIL, incubation and applied research; a key finding of this research is absence of involvement by UAE innovation ecosystems in international knowledge networks, which is only likely to decrease if firm generate or have access to richer applied research. The foundations of UAE's innovation ecosystems are then readily explicable in terms of the figure 3.1 framework.

8.3.3 Sub-Research Question 2

"How policymakers and entrepreneurs perceive that the challenges facing the innovation ecosystem in the UAE?"

The challenges facing UAE's innovation ecosystems are being met partially and incrementally. Referencing the figure 3.1 framework (1): start-up rates in advanced technologies will improve, if as R-17 suggests incubators cement closer relations with trading businesses and transfer more tacit knowledge. Since 60% of graduates and women but only 30% of innovators, measures to increase women's start-up rates in advanced ecosystems are necessary. Bich (2021) comments (without detailed evidence) on the importance of building human capital and Guerrero and Urbano (2012) note the lack of research on UAE. This research supports Gan *et al* (2020) and Toan's (2021) findings that drawing women entrepreneurs into development pathways is critically important to speed of development. Firms seeking legitimacy (2) overcome the *liability of newness* up to a point. Increased use of venture capital may spur drives to increase international sales (currently 10 to 20%) and more applied research, if it flows into start-ups may increase inclusion in international knowledge networks. Resource marshalling (3) is likely to improve as new proof of concept grants increase and if tacit learning from businesses increases because of UIL strengthening. Knowledge flows (4) are likely to take time to improve as education and university commercialisation reforms take effect and emphasis on informal learning increases.

No single organisation appears responsible for monitoring and recommending changes in UAE's advanced technology ecosystems. It may seem perverse to point to such responsibility for structures (ecosystems) characterised by absence of central coordination. However, one organisation mapping ecosystem change, barriers and making policy recommendations does not mean coordination, instead is offers the leadership section-7.5 argues is necessary. Such leadership is in the realm of ideas not control of practice. Responding to the challenges facing UAE's innovation ecosystems is occurring, the pace of change and improvement would increase with leadership.

8.3.4 Sub-Research Question 3

"How the knowledge-based innovation ecosystem operates at the meta level in the UAE?"

The nature of ecosystem is that they evolve emergences, including structures: there cannot be central design or control. Meta-trends (8) in figure 3.1 and meta-governance changes (7) discussed in section 7.7 and 7.8 are by definition outside the control of a rule-taker, small country such as UAE. These finding support the conclusions of Baglieri *et al* (2019) and Leydesdorff and Ivanova (2020). Key to avoiding insularity or lack of synchronicity with evolving meta trends and governances will be the ecosystems' ability to interpret weak signals heralding change. Doing so requires closer proximity to important large companies shaping new products and influencing governance changes. Masdar City and existing technology clusters may help the nascent ecosystems. Fundamentally, the innovation ecosystem structures, and mechanisms have evolved in the current UAE context and culture. If some of the risks discussed in sections 7.7 and 7.8 materialise, it is likely that UAE's fragile innovation ecosystems will suffer. However, current technological trends and current governances have shaped the emerging innovation ecosystems' structures and ways of working and an optimistic perspective suggests they can evolve with trends and governances to flourish. The characteristics for ecosystem that successful migrate and evolve to meet change (table 2.1) affect only UAE's innovation ecosystem but that of its competitors, key points from the figure reiterate the discussion above: progress needs to be measured (if we don't count, we don't count) and evidence-based policy recommendations flow from hard facts. This does not appear to be happening currently.

8.4 Final Framework: Innovation Ecosystem in the UAE

Having built on Linstone's (2011) ideas of multiple perspectives and scaling, incorporating concepts of ecosystems, complexity and learning and embedding the forty-three factors constituting innovation ecosystems in a resource rich context; figure 3.1 was presented to conceptual guide this research. Section 4.1 noted the exploratory nature of this research, meaning that definitions, meanings and interpretations would emerge during the research. Additionally, the research strategy justified in chapter 4 included the use of Charmaz's (2017; 2019) constructed grounded theory: the idea that after trawling literature to create an initial investigative framework a final framework could be created with amendments grounded in the evidence from the research. This section revisits the figure 3. framework amending the themes and relationships shown since evidence from the research: these are shown in figure 8.2.

Theme (7) in figure 8.2 is amended from meso to meta for consistent use of terminology and in addition, risks and alliances are added as features in the ecosystem environment that are important reflecting the discussions on risks section 7.6 and importance of alliances with large companies and inclusion in international knowledge networks. Also, in theme (8) political "events" seems more appropriate than "upheavals" i.e. suggesting that even less radical political occurrences may impact on the emergent ecosystems.

In the outer layer, representing UAE's institutions, the duplicated "New ecosystem" box is now replaced by "Education, university and corporate R&D and commercialisation support" to reflect one other significant findings of the research that though UAE's education and research capabilities may be better than other developing country innovation ecosystems, improvement in these factors is necessary if new products are to be developed in the target technology ecosystems.

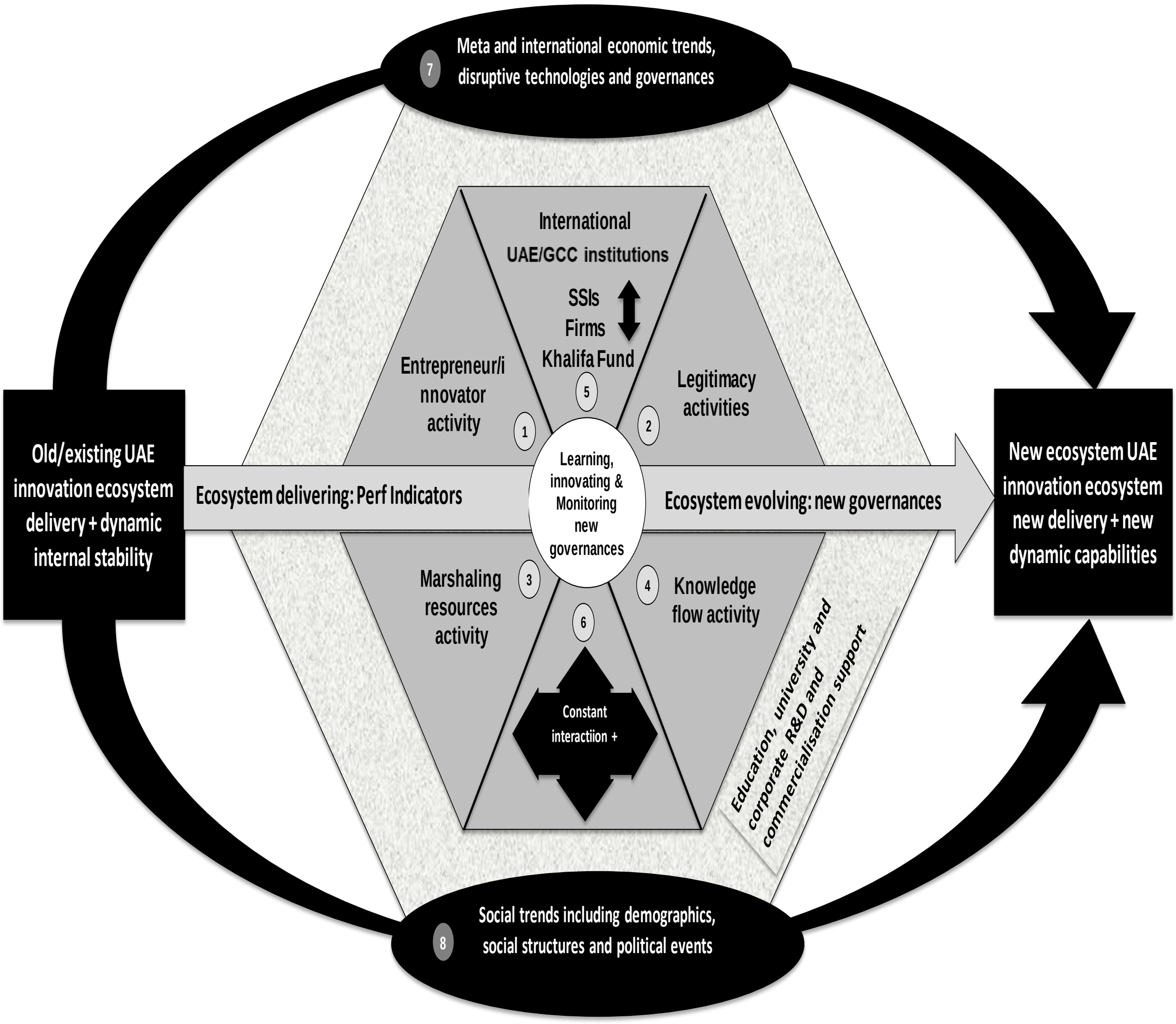


Figure 8.2: Framework-2, multiple views of innovation ecosystem in The UAE

On the right-hand side of the figure "dynamic stability" is replaced by "dynamic capabilities" reflecting the continuous nature of change in innovation ecosystems. At the centre of the figure, learning, innovating & new governances" is amended to include monitoring; this indicates the need for mapping and monitoring of the emergent ecosystems i.e. leadership of the policy agenda impacting on the ecosystems.

Figure 8.1 now represents one of the major theoretical contributions of this research. Its usefulness for this research is indicated by the 45 references to it in the thesis and the continual referencing of the themes and categories of factors represented in the figure.

8.5 Validity and generalisation

Section 4.6.3 discussed the validity the present research and addresses both the internal and external validity and the criterion for validity. Table 1.2 summaries the linkages between research questions, data, method and analysis. These guidelines have been followed; the actual flow of the thesis demonstrates this internal validity. Presentation of conclusions has followed the advice of Nicholson *et al* (2018), of Llewelyn (2002) in claiming intermediate theory development with limited generalisation and of Corbin (2009) and Charmaz (2019) in encapsulating theoretical conclusions is a framework-2.

Throughout the thesis external validity is shown by referencing previously published research and relating to it the arguments and evidence in this research. Table 7.11 summarises how the results of this research and previous research correspond. Additional external validity arises from the numerous policy recommendations flowing from the research. Conceptually, the research was guided by the figure 3.1 framework 1, embedding concepts and relationships from previous research, suggesting validity in the research field.

In discussing generalisation from this research, section 4.6.3 argued that simple transfer of ‘lessons’ from UAE’s context and culture to another is inadvisable, since agent roles, meanings and unforeseen consequences vary between innovation ecosystems. Certainly, any use of this research in a different context should include a deep re-contextualisation, investigating how roles and relationships vary between the contexts. Echoing Alasuutari’s (1995) admonition of care in generalising research results, it remains the case that the framework developed in this research may be of generalisable use, especially in countries evolving innovation ecosystems that are resource-rich yet under-developed: Kazakhstan, Ghana and other oil states come to mind.

8.6 Policy implications

Part of the motivation for this research is that as an Emirati who is proud of the country and its achievements, the research may help support and strengthen innovation ecosystems and help meet the *Vision 2030*, which is shared by the author. five important recommendations for public policy flow from the research.

- Innovation ecosystems are necessarily uncoordinated and uncontrolled since autonomous agents respond to events and decisions in unforeseen ways and with unforeseen consequences. However, as the research shows, these agents are in turn influenced by meta-trends and governances and the results of public policy. Mapping the progress and barriers facing the emergent ecosystems would allow evidence-based input into a range of public policy making and implementation processes. Such mapping and monitoring do not mean central control of the innovation ecosystems, which would diminish innovativeness. UAE should ask one agency, such as the KF, to conduct an annual mapping and monitoring of the emergent innovation ecosystem, from which a short list of practical, measurable and achievable policy suggestions might flow. Detailed metrics based on the figure-8.1 framework could be used for these exercises.
- The knowledge economy requires knowledge workers and UAE's education system, while perhaps superior to many developing economies, is not competitive with the leading economies it wishes to join. Reforming education is a complex and long-term project. In this case it might begin by adopting action learning pedagogy, removing rote assessments and replacing them with problem-solving projects. Education should feature closer links with business (entrepreneurship education, visits, projects, speakers, case study work). Deep benchmarking and exchanges with high-performing education systems such as Finland, may help this process.
- Similarly, the universities need deep reform in teaching and research. A similar approach to school should be adopted for pedagogy. Universities should be further encouraged to strengthen UILs in joint and contract applied research. Existing arrangements are improving publication and patenting (formal knowledge) but not yet impacting on informal knowledge transfers into the emergent innovation ecosystems. Monitoring of spinouts is urgently needed. Incubation centres should

be led by experience (often international) businesspeople not academics. Incentives to researchers should be explored such as the third-third-third (university, company and researcher) used in many US universities. Commercialisation models deeply involving trading business should be benchmarked, for example the Indian Institute for Information Technology model in Bangalore.

- Few countries seem happy with bank support to knowledge-based start-ups and UAE is no exception. Venture capital availability would increase with the creation of a private equity market and reform of capital gains taxes. Agencies such as Scottish Enterprise and Biotechnology Boston have influenced these matters and may be benchmarking partners for the KF if it is given a leadership role.
- Finally, too many entrepreneurial young Emiratis work in Government. The idea of entrepreneurship is a pathway migrating state employment and assets into companies and may be a model for UAE to follow. Secondments to companies of Officials working in areas effecting technology innovation ecosystems is a good way to influence policymaking and implementation.

UAE has set ambitious target in Vision 2030 and a short timescale. This research concludes that urgent actions in the areas above is necessary otherwise, while progress is likely to be made the sustainable innovation competitive with elite countries may be missed.

8.7 Further research

Two immediate areas of further research flow from this research. Firstly, a survey of twenty-seven companies is small and limited (in this case to companies recommended by the KF). A major survey of UAE companies associated with the innovative ecosystems is needed, providing data to feed into a wider evaluation of the ecosystems. Secondly, closer ethnographic case studies of successful and unsuccessful companies in the target technology ecosystem are needed to understand more closely the barriers to growth (such as membership of international knowledge networks, international trading and absence of university links). While this research is useful, deeper work into the processes at company level of ecosystem-building is necessary.

8.8 Research Dissemination & Future publication

A summary version of this research will be prepared and presented at a strategy meeting of the KF, hoping to begin the processes of the KF considering the policy recommendations.

Two press articles will be prepared in Arab language newspapers summarising the results of this research, contributing to on-going debates within UAE.
Three academic papers are already in preparation from this research, these are shown in table 8.1.

Contribution	Target journal	Time and target
Empirical contribution based on the quantitative survey and mapping of UAE's ecosystem	*International Journal of Technology Management*	Submission: Currently drafting
Applying ecosystem theory to the Arabic context	*Technovation*	Submission Mid-2021
A theoretical piece on innovation ecosystems in resource rich contexts demonstrating the usefulness of the conceptual framework	*Research Policy*	Submission Late 2021 At planning stage

Table 8.1: Target academic publications

As a sign-off this research journey has been stimulating, sometimes exacting and always enjoyable. I hope it allows me to contribute to my country's future. My gratitude to my supervisors is boundless.

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