Understanding How High-Tech Entrepreneurs Successfully Pivot Their Startups as Part of the Entrepreneurial Journey

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Statement of Original Authorship

The work in this thesis is based on the research carried out at the Nathu Puri Institute for Engineering and Enterprise (NPI), School of Engineering, London South Bank University. No part of this thesis has been previously submitted to meet the requirements for an award at this or any other higher education institution.

Abstract

Purpose: In their entrepreneurial journey, high-tech entrepreneurs continuously face a need to devise a competitive value proposition for the startup company and leverage emerging technology to strengthen the proposition. Entrepreneurial pivoting addresses this challenge by allowing startups to validate and refine both their strategy and business model. Therefore, the research study has investigated two theories: the Lean Startup Approach and Technology Entrepreneurship. Consequently, the study has provided an empirical investigation of the pivoting concept examined in the context of the Lean Startup approach (LSA) and Technology Entrepreneurship to improve the understanding of the entrepreneurial journey for high-tech entrepreneurs.

The research also focused on understanding how the life cycle stage of an emerging technology impacts the high-tech entrepreneurs' entrepreneurial journey. The Lean Startup Approach, the technology S-curve, and the technology readiness level (TRL) framework were investigated to address the above question. The study has provided an empirical investigation of the pivoting concept, which has been explained in the context of the lean startup approach (LSA), the technology S-curve and the technology readiness level to improve the understanding of the entrepreneurial journey for high-tech entrepreneurs leading tech startups.

Apart from investigating how high-tech entrepreneurs develop competitive value propositions and how emerging technologies impact their entrepreneurial journey, the research study also investigated leadership styles and their influence on tech entrepreneurs. For this, the study has empirically investigated pivoting from the Lean Startup Approach and six different leadership styles. Due to studying pivoting from the Lean Startup Approach and investigating technology entrepreneurship, technology S-curve and technology readiness levels, this research study is titled 'Understanding how high-tech entrepreneurs successfully pivot their startups as part of the entrepreneurial journey'.

Methodological Approach: A qualitative research method was adopted by interviewing high-tech entrepreneurs across the United Kingdom to validate the theories associated with the LSA and identify new insights on entrepreneurial pivoting. The interviews are divided into two stages. Firstly, thirty primary interviews were conducted to understand pivoting and the factors that trigger pivoting; the influence of the phases of technology entrepreneurship on pivoting; and the impact of stages of technology maturity in the technology S-curve on pivoting. Secondly, longitudinal interviews were conducted in three phases with nine high-tech entrepreneurs who were also involved in the thirty primary interviews. The purpose of the longitudinal interviews was to collect further data on the above-mentioned topics and understand in more detail and build up a richer picture on how high-tech startups successfully pivot as part of the entrepreneurial journey.

Findings: The research study has validated the existing types of pivots and identified two new pivots (giving 16 in total). The study has validated 11 factors that trigger a tech startup to change direction and identified three new factors (giving 14 in total). The research study also determined that there can be a domino effect in pivoting, and the value proposition can be created and sustained through pivoting. The study has established the influence of the phases of technology entrepreneurship on pivoting and the impact of the stages of technology maturity in the technology S-curve on pivoting.

Originality: The study provides empirical evidence on pivots and the factors associated with pivots. Moreover, the study significantly helps to improve the understanding of the influence of the phases of technology entrepreneurship on pivoting. The study has developed a new conceptual framework for TE. Furthermore, the study helped in understanding the impact of

the stage of technology in the technology S-curve and technology readiness level on pivoting. The study also discusses the challenges faced by tech startups while pursuing pivots; the domino effect in pivoting; and has found evidence that pivoting leads to achieving the desired results.

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List of Abbreviations

BML:	Build Measure Learn Principle
BVCA:	British Venture Capital Association
LSA:	Lean Startup Approach
MVP:	Minimum Viable Product
TE:	Technology Entrepreneurship
TLC:	Technology Life Cycle
TRL:	Technology Readiness Level

Chapter 1: Introduction

1.1 Research Overview

Entrepreneurial research is an emerging domain that has received much attention in recent decades (Landstrom and Benner, 2010). For example, many researchers have studied entrepreneurial actions and the fundamentals of their existence as well as the impact on economic development (Baumol et al., 2007). As a result, researchers have identified that entrepreneurship is crucial for economic development, making it essential to understand how entrepreneurs successfully create employment as well as produce and execute innovative technologies (Ferreira et al., 2019). Indeed, Frank and Landstrom (2016) explained that entrepreneurial research has evolved by studying startups and small firms to embrace theories from different fields and generate new entrepreneurial behaviour approaches within large-scale companies, i.e., intrapreneurship.

Although Cantillon (1755) was one of the first to define entrepreneurship, Knight (1921) was the first to explain entrepreneurship as the ability to handle uncertainty in any society. Later, Schumpeter (1965) defined an entrepreneur as an individual who identifies an opportunity and commercialises it with the help of technical and organisational innovation (Eroglu and Picak, 2011). The first course on entrepreneurship and innovation was conducted in 1953 at New York University in the United States by Peter Drucker. In 1948, the problems of small-sized companies were explicitly addressed by the International Council of Small Business, ICSB (earlier known as the National Council for Small Business Management Development) in Switzerland. Subsequently, conferences, societies and research committed to entrepreneurial issues grew worldwide (Ferreira et al., 2019).

Historically the economist Schumpeter defined entrepreneurship as *"carrying out new combinations"* (Low and MacMillan, 1998, p. 140). Academic scholars have shown interest in two special issues in entrepreneurship: *"origin of opportunities and nexus of opportunity and enterprising individuals"* (Venkataraman, 1997, p. 121). Entrepreneurship research is a multidisciplinary and application-oriented domain with multiple levels of analysis, which is similar to the information technology (IT) and marketing fields (Gartner, 2001). To explore the entrepreneurship process, one must first understand the creation of different levels, such as individual, team, organisation, industry, and community. Therefore, entrepreneurial research consists of understanding individual behaviours and how individuals identify and commercialise opportunities, also directing an organisation towards growth (Brush et al., 2003). This leads to the emergence of industry, new venture developments and wealth creation (Brush et al., 2003).

A primary focus in the field of entrepreneurship and its research is *"creation"*. It can occur at multiple levels, for instance, at the individual, team, organisation, or industry level. It is essential to understand creation in order to study the entrepreneurship process. A venture, an organisation, or a new product or service is viewed as a creation. The study of entrepreneurship also involves the study of behaviours of individuals as they are the ones who identify the opportunities, thereby leading to the creation of new teams, ventures, or organisations. It also encompasses wealth creation and organisational transformations. Therefore, entrepreneurship study focuses not only on opportunity identification but also on resource acquisition, venture capital investments, franchisor development and international entrepreneurship (Brush et al., 2003).

Vecchio (2003) explained that the field of entrepreneurship has traditional roots in the field of leadership and management. In the literature, an entrepreneurial profile is described in five attributes. An entrepreneur is expected to have a risk-taking propensity, i.e., an individual whose decision is inclined towards a more significant potential reward even though there is a likelihood of loss at present. Nonetheless, research has not shown any clear evidence of the relationship between the entrepreneur and their risk-taking propensity. Successful entrepreneurs are not able to be distinguished based on risk-taking propensity from unsuccessful entrepreneurs. However, some studies have reported that entrepreneurs have a high risk-taking propensity when compared to managers. Indeed, studies by McClelland and Winter (1969) on classic conceptions of basic needs moderately support the position that there are specific expected differences between entrepreneurs and others. The motivation for achievement is somewhat associated with a startup's performance. Research has reported that entrepreneurs have higher motivation for achievement when compared to managers of multinational companies (MNCs) or managers of small businesses. However, in another study, the results did not support the above statements, and the need for achievement has not yet been credibly associated with an entrepreneur's success or failure (Vecchio, 2003).

The need for autonomy and the need for achievement are often thought to be factors of the entrepreneur's motivation. Despite a general belief that an entrepreneur is 'independent' and 'self-directing', a lack of empirical evidence at present does not support this theory. Moreover, Bandura's (1982) work on social learning theory states that individuals tend to prefer situations in which they have high personal control and avoid situations in which they have low control. Implementing this concept to entrepreneurial activities suggests that people with high entrepreneurial self-efficacy may look for more opportunities compared to people with low entrepreneurial self-efficacy who will necessarily focus more on costs and risks. A comparison conducted between small business founders and non-founders has shown that founders tend to have a higher degree of entrepreneurial self-efficacy (Vecchio, 2003).

Locus of control is the broader concept of self-efficacy, although the study of locus of control when applied to the field of entrepreneurship has showed poor results. Researchers used scales developed by Rotter (1966) or Levinson (1973) but could not distinguish between small business owners and employees or between founders and non-founders on the aspect of locus of control. Even though conceptual claims about the role of control in entrepreneurship can be convincing, the evidence is not so strong (Vecchio, 2003).

The field of entrepreneurship is a multi-dimensional area of study, which derives from many disciplinary areas, and it has many branches; one such branch is technology entrepreneurship (TE). Technology entrepreneurship has gained much attention from researchers, practitioners, and policymakers in recent decades as they have acknowledged the positive influence of TE on economic growth (Mosey et al., 2017). Furthermore, technology entrepreneurship is a well-defined field of research at the intersection of entrepreneurship and the management of technology and innovation (Spiegel and Marxt, 2011). Therefore, the concept of TE is considered an interface between innovation and entrepreneurship (Ferreira et al., 2015; Schmitz et al., 2017).

In the era of digitalisation, innovation and technology play a vital role that startups leverage to be sustainable and contribute towards economic growth. However, startups need to harness technology in order to remain competitive. This research study investigates the 'high-tech' area of entrepreneurship, which emphasises technological innovations. Indeed, the British Venture Capital Association (BVCA) defined the high-tech sector as including communications systems, software technology, internet technology, semiconductor technology, biotechnology, medical, instrumentation and medical pharmaceutical and other electronics-related technologies (Vohora et al., 2004).

A high-tech entrepreneur is an individual who uses their training and professional experience to assess and devise new ideas with high growth prospects and to meet industrial needs. The study herein focuses on scientists, engineers, and people from other educational backgrounds whose startups are closely related to their education. As such, these individuals use their professional experience to evaluate opportunities that arise during their employment or research study and exploit their knowledge to commercialise ideas or opportunities (Braguinsky et al., 2012).

Technology entrepreneurship provides significant advantages and spillover effects to regional economies. For example, commercialising innovative ideas in the market leads to economic growth. One of the critical factors to promote and sustain TE is the investment by regional economies in R&D. Universities also contribute towards TE by encouraging more spin-offs and integrating entrepreneurial elements in their overall course curriculum, knowledge exchange and technology transfer activities (e.g., hosting incubators and accelerator programmes) (Cunningham and Link, 2015). Economies that encourage the establishment of TE regions often seek to mimic the characteristics of Silicon Valley in California (USA) or through the development of special economic zones to encourage high-tech entrepreneurs who will benefit through producing pioneering products and creating high-value-added jobs as part of high-tech innovation ecosystems (Cunningham and Menter, 2021).

In 2008, a UK Department for Business, Enterprise, and Regulatory Reform (BERR) report revealed that the strategy of the government was to make the United Kingdom (UK) the most enterprising economy in the world and the optimum location to set up a business startup. However, the business statistics in the United Kingdom (UK) for 2021 show that total new business startups are up by 31,000 from the previous year. The number of existing businesses that ceased in 2021 totalled 327,000, up by 28,000 compared to business deaths in 2020. The business birth rate in the year 2021 was 12.4%. By contrast, the business death rate was 11.1% in 2021 (Hutton, 2022). To accomplish the vision of an enterprising economy, one must enhance entrepreneurial aptitudes within schools and higher education institutions (Jones and Colwill, 2013). In addition, entrepreneurship education is considered a meaningful way to influence the competitiveness of any economy or industry. Entrepreneurship education typically tends to be based on a programme that teaches skills to start and manage a growth business. Furthermore, in recent times, this has changed as students are more interested in acquiring knowledge regarding entrepreneurial behaviour rather than just learning how to start a venture (Ratten and Jones, 2021).

How does an entrepreneur create value? Indeed, do they know how they create value? In order to answer these questions, we either need to approach a successful entrepreneur, or we can search in the literature about the methods and the practices they follow. It can be observed that some entrepreneurs are palpably better at creating value than others (Nightingale and Coad, 2013). What if we can understand how they created higher value to improve the survival rates of startups or ventures. Its impact would be significant in society (Frederiksen and Brem, 2017).

Eric Ries, an entrepreneur, and author of *The Lean Startup* defined a startup as a human institution intended to design new products and services under conditions of dubiety (Ries, 2011). Ries also explained that the productivity of startups is not just about developing new features but also involves aligning all efforts to create and sustain a value proposition. Authors like Blank (2013), Ries (2011), and Osterwalder and Pigneur (2010) are some of the key contributors to the lean startup framework (Shepherd and Gruber, 2020). The word lean is often misconstrued as the startup is bootstrapping, i.e., keeping its cost as low as possible and relying on the founder's resources for capital investment (Eisenmann et al., 2012).

Instead, the lean startup framework adopts the same overall perspective of lean manufacturing, i.e., avoiding waste (Eisenmann et al., 2012). The Lean Startup Approach therefore involves the implementation of lean thinking into the process of innovation and startup activity. It is believed that the foundation of Toyota's success can be utilised to enhance the rate at which the startups can find so called validated learning. The approach argues that the implementation of lean will lead to startup formation and eventually a successful business enterprise (Felin et al., 2019). The Lean Startup Approach (LSA) introduced two main concepts, which are the

Minimum Viable Product (MVP) and pivoting. MVP is defined as developing a prototype of a product or service and releasing it in the market. Based on the customers' feedback, there is the possibility of improving the product with the least effort. Indeed, a study conducted on 227 digital startups in Italy to understand how they adapt and implement LSA found that LSA is an operational, systematic, and scientific decision-making tool for entrepreneurs as it helps create opportunities (Ghezzi, 2019). Furthermore, Ries (2011, p. 149) defined a pivot as "*a structured course of correction designed to test a new fundamental hypothesis*".

The need to leverage technology is one of the fundamental challenges of a tech entrepreneur. Furthermore, to leverage technology, the tech entrepreneur has to forecast the performance of the technology. Why is the forecasting of technology important? Any startup which can be affected by technological changes will effectively be engaging in technology forecasting. Moreover, the continuous evolution of technology can set a tech startup towards a path of growth or decline. It has been reported that technology forecasting has the capacity to help tech startups achieve the following objectives (Martino, 1993a):

1. To have a competitive edge compared to other tech startups in the industry.

2. To forecast capital planning in terms of investment in the technology.

3. To identify limits beyond which it is impossible to use the technology.

4. To identify any alternative technology that offers higher performance.

5. To develop a standard plan for the startup. In addition, a startup can compare its plan with a forecast to take further decisions.

The innovation diffusion theory deals with the innovation process, which characteristically exhibits an S-pattern. A study by Utterback and Abernathy (1975) articulates the innovation process as an S pattern (Wonglimpiyarat, 2016). The technology S-curve has multiple names, such as the Growth curve, S-shaped pattern, Logistic curves, Gompertz curve, Saturation curve, Sigmoid(al) curve, Foster's curve, Bass model and many more (Kucharavy and De Guio, 2011). It depicts the growth in the performance of technology over time. A growth curve or S-curve is used to predict how and when technology will reach its upper limits (Martino, 1993). The progression of the technology at first advances slowly, followed by rapid growth and then inevitable decline. Thus, confirming to a general form of an S-shaped curve. In technical literature, the use of the S-curve is far more consistent (Taylor and Taylor, 2012).

Academic scholars have explained innovation as a process of enhancing existing technology or the process of exploiting new opportunities into a viable solution. The S-curve model is considered as a substitution for the 'Product Life Cycle' (PLC). PLC involves the phases of introduction, growth, maturity, and decline, just like the S-curve's development pattern. Other models, such as the Innovation Life Cycle model, the Gregory technology management model and the Rothwell innovation model (Wonglimpiyarat, 2016), have been considered while conducting this research study. However, the above models do not allow technology to be considered from a temporal or time-based perspective and allow the level of technology maturity or adoption to be assessed. A high-tech entrepreneur can potentially use the S-curve to identify inflexion points and assess the maturity stage of the technology so that they can understand the growth and saturation of technology and decide whether to pivot or persevere. The technology S-curve model, therefore, provides a valuable lens for the research study to consider the impact of technology on the entrepreneurial journey and, specifically, the phenomena of pivoting.

1.2 Focus of research study

The focus of this research study is to understand the process of pivoting pursued by tech startups. In order to do so, the research study was focused on three different underpinning conceptual frameworks. Therefore, a detailed literature review was conducted on technology entrepreneurship, the Lean Startup Approach, and the technology S-curve. Figure. 1 illustrates how the research study links the three different conceptual areas with each other. The concepts of entrepreneurial pivoting and technology entrepreneurship were studied together to understand the influence of TE phases on entrepreneurial pivoting. Additionally, the concepts of technology forecasting through the technology S-curve and entrepreneurial pivoting were studied to understand the impact of the stages of technology maturity on pivoting.

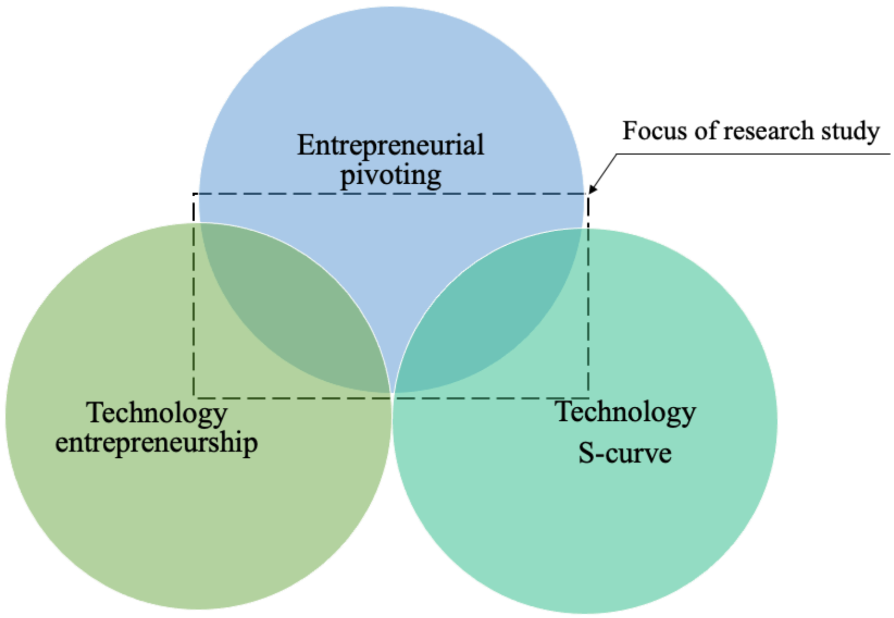

Figure 1. Interlink between three conceptual theories.

1.3 Research aims and objectives

1.3.1 Aims

The research study has the following aims:

1. To critically evaluate the concept of entrepreneurial pivoting and how high-technology entrepreneurs successfully pivot as part of the entrepreneurial journey.
2. To analyse the role of technology entrepreneurship and the effect of technology maturity in the entrepreneurial pivoting process.

1.3.2 Objectives

The research study has the following objectives:

1. To investigate practicing entrepreneurs through identifying the types of pivot that can be pursued by a tech startup.
2. To identify the factors that trigger pivoting by tech startups.
3. To investigate the influence of the phases of TE on entrepreneurial pivoting.
4. To understand at which phase of TE the entrepreneur has adopted pivoting and why.
5. To investigate whether different types of pivots can be classified according to the phase of TE.
6. To investigate the impact of technology in the technology S-curve on entrepreneurial pivoting.
7. To understand at which stage of technology in the technology S-curve a tech entrepreneur prefers to pivot and why.
8. To investigate whether different types of pivots can be classified according to the stages of technology in the technology S-curve.

1.4 Research strategy

1.4.1 Research philosophy

Research philosophy applies to a system of credence and relates to the hypotheses about knowledge development. A research philosophy that is well thought-out with consistent assumptions will mould the researcher's understanding of research questions, methodology, data collection techniques and analysis procedure. For a pragmatist, reality matters. For them, research starts with a problem and aims to contribute to research with a practical solution. According to pragmatist research, the most critical determinant of a research design and strategy should be a research question that addresses the research problem (Thornhill et al., 2009). Pragmatism means action, and it was derived from the Greek word pragma (pragma).

The words' practice' and 'practical' came from pragma. In 1878, Charles Sanders Peirce introduced the concept of pragmatism in the article *"How to make our ideas clear"* (Dewey, 1916) and later developed by Pansiri (2005).

A pragmatic research approach is considered the most practical method as it helps a study employ various techniques to address the research question(s). According to the study by Teddlie (2005), identifying a methodology which assesses a researcher's values and research study is significant for uncovering answers which is a fundamental characteristic of this approach. Similarly, Coyle (2010) mentioned that pragmatic research aims to improve overall understanding instead of only looking for facts or validity. Indeed, Johnson and Onwuegbuzie (2004, p. 18) remarked "*A pragmatic methodology aims to find a middle ground between philosophical dogmatisms and scepticism to find a workable solution."* This approach helps focus on listening to the interviewees and understanding their viewpoints (Clarke and Visser, 2019). Therefore, this research study has adopted a pragmatic research approach. The research study identified the knowledge gap between the academicians and the practitioners i.e., how the practitioners (tech entrepreneurs) successfully pivot their tech startups as part of the entrepreneurial journey. The research method and research questions were identified to address the above-mentioned knowledge gap.

1.4.2 Research method

Busenitz et al. (2013) mentioned that an extensive literature review and a thorough research methodology are essential for an improved research outcome. Researchers in the field of entrepreneurship employ both quantitative and qualitative methods. However, quantitative research methods appear to dominate in entrepreneurship. Although some researchers, such as Gartner and Birley (2003) and Hindle (2004), have stressed that qualitative techniques in the entrepreneurship research field can also address critical questions. However, the quantitative technique is more relevant for asking *"how many, how often or causal relationships between* *variables"*. In qualitative research, open-ended questions, like why, what or how can be used to explore and understand the experience of interest in greater detail. The responses are primarily in textual format in qualitative methods, and they are analysed using qualitative techniques. The qualitative technique studies the behavioural aspects of research, and it helps to gain a holistic understanding of the process in a specific scenario (Molina-Azorín et al., 2012; Trumbo, 2004). The scientific canons of qualitative research include significance, theory-observation compatibility, consistency, reproducibility, precision, and verification. These canons can be achieved using grounded theory as part of the qualitative research approach (Corbin and Strauss, 1990).

The first step in the research study is to perform a literature review that in this case captures supporting academic concepts on entrepreneurial pivoting and the factors that trigger pivoting. Thus, to understand the S-curve theory about the technology lifecycle. The literature review has helped to identify and evaluate conceptual knowledge and understand the gap between existing theories and current practices in technology entrepreneurship, entrepreneurial pivoting, and the technology S-curve. The next step (second step) in the research study was to analyse secondary data to initially understand the types of pivots pursued by the tech startups and the factors behind those pivots. This was followed by empirical research through interviews (third step) to investigate how practising high-tech entrepreneurs' pivot; what phase of technology entrepreneurship they pivoted their tech startup in the entrepreneurial journey; and to help understand how the technology lifecycle impacts pivoting. The data gathered from the qualitative study has helped in understanding the startup's success rates after pivoting.

1.4.1 Research planning

The data collected through the thirty primary interviews helped validate the types of pivots and the factors that trigger pivoting. The qualitative analysis of the first 30 interviews determined new pivots and factors as well as the influence of technology entrepreneurship and technology life cycle on pivoting. This information was vital in conducting longitudinal interviews with nine tech entrepreneurs who were identified from the 30 previous interviewees. The research aimed to fill the gap between practitioners and academicians and explain the link between three different theories i.e., entrepreneurial pivoting, technology entrepreneurship and the technology life cycle. In order to achieve this strategy, it was decided to publish the findings in leading journals and present them at conferences. See the Appendix for a list of research publications arising from the study.

1.5 Structure of the thesis

Chapter 1 is the introductory chapter which describes the overview of this research study. This chapter presents the concepts such as entrepreneurship, technology entrepreneurship, the Lean Startup Approach, entrepreneurial pivoting, and the technology S-curve. In this chapter, the research aims and objectives, as well as the research strategy (namely research philosophy, research method, and research planning), are explained.

Chapter 2 provides the literature review for this research study. Firstly, the literature review includes details on technology entrepreneurship, the lean startup approach, entrepreneurial pivoting, technology s-curve, technology readiness level (TRL) and types of leadership skills. Secondly, the literature review provides the conceptual framework and the specific research questions that are derived.

Chapter 3 explains the conceptual framework and why it is helpful for a research study. This chapter describes the conceptual framework developed by the study for the research. In the chapter, the study has explained the research questions designed after conducting the literature review.

Chapter 4 illustrates the methodology used in this research study, including the steps involved in qualitative analysis and how the data was collected. This chapter explains the procedures involved in the qualitative analysis. The methodology chapter consists of details of the participants, such as their role in a startup, professional experience, and the number of startups they launched. The chapter also includes details on the collection of secondary data to improve the understanding of entrepreneurial pivoting further.

Chapter 5 provides the results of the secondary data. The quantitative data analysis explained the pivots pursued by eighty tech startups/companies and the factors that initiated those pivots. In this chapter, the study discusses the outcome of the data analysis and how it helped collect primary data.

Chapter 6 This chapter explains the empirical evidence from qualitative analysis of thirty primary interviews. The chapter illustrates and validates various pivots and factors that tech startups pursue. The study describes the results in the discussion section and links them to the literature on entrepreneurship and LSA.

Chapter 7 This chapter shows the empirical evidence about the influence of technology entrepreneurship as well as the impact of the stage of technology in the technology life cycle on pivoting. The chapter also explains the domino effect of pivoting and the challenges tech startups face while pivoting. The study describes the results in the discussion section and links them to the literature on entrepreneurship, technology entrepreneurship and the technology S-curve.

Chapter 8 This chapter illustrates the qualitative data analysis of longitudinal interviews. The empirical results explained how tech startups performed during COVID-19 and their viewpoints on what type of pivots can be pursued at different phases of technology entrepreneurship and the technology S-curve. The study also explains the influence of TRL levels on pivoting and psychological ownership issues faced by tech entrepreneurs in this chapter. The study describes the results in the discussion section and links them to the literature on entrepreneurship, LSA, TRL framework and leadership.

Chapter 9 provides discussions based on the empirical evidence through qualitative data analysis while addressing the research questions. This chapter illustrates the implications for policymakers and practitioners and links back the empirical evidence with the existing literature. In this chapter, the study summaries the entire research study to explain how the knowledge gap has been addressed, the contribution to the literature on entrepreneurial pivoting, the limitations of the study and future research work. Figure 2 provides a schematic view of the structure of the thesis.

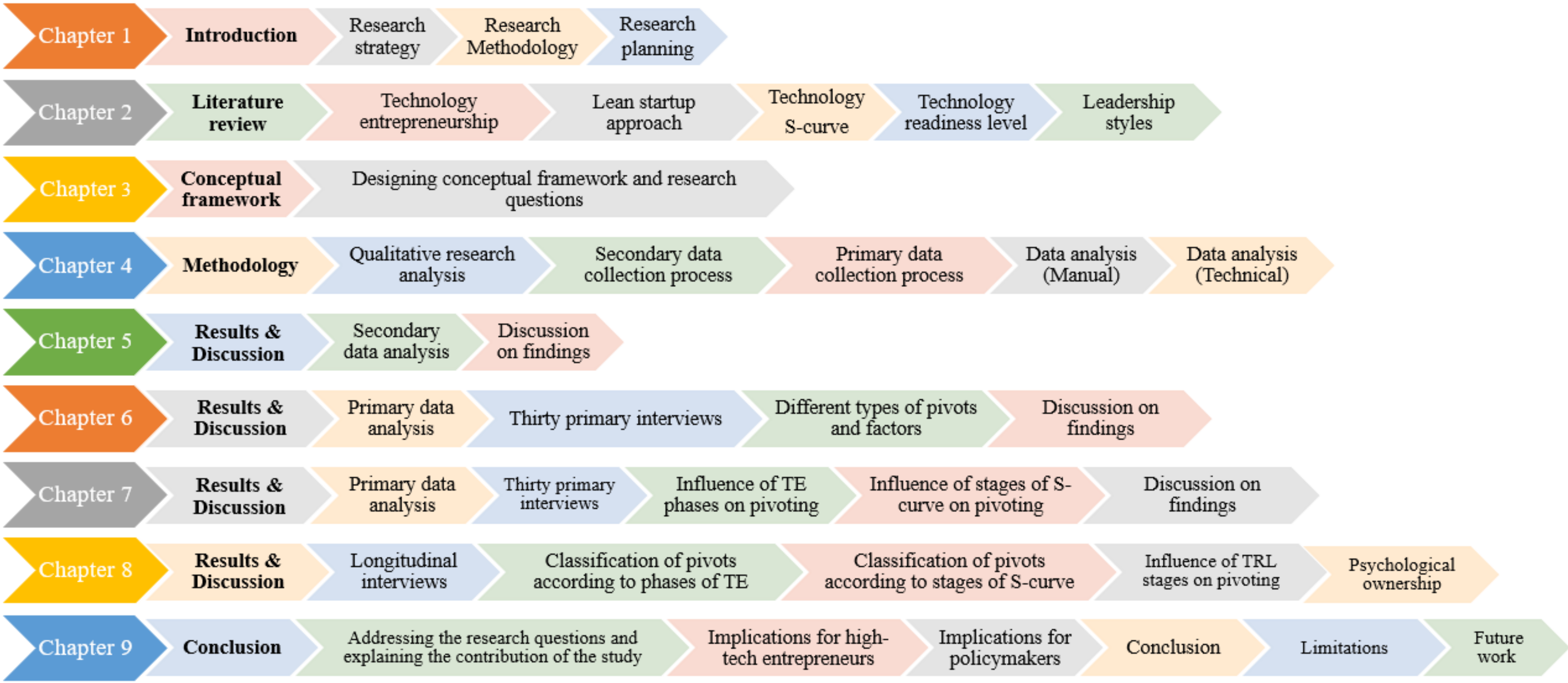

Figure 2. Structure of the thesis

Chapter 2: Literature review

2.1 Introduction

In academia, it is vital and valuable to learn about the current state of research in each area of specialisation, either for completing a doctoral thesis or publishing a research article. Therefore, a sound knowledge of the prior literature is required to avoid studies lacking originality or essentially repeating previous work. Literature in any discipline typically describes the progress of knowledge and an improved understanding of associated concepts, theories, methods, and phenomena. However, unanticipated growth in literature can hinder a research study by raising the possibility of contradictory arguments in the ongoing research. Indeed, Webster and Watson (2020) indicated that reviewing previous and relevant literature is essential to any research study. Researchers aiming to publish their research must understand the discipline's supporting literature. Jones and Gatrell (2014) and Palmatier et al. (2018) mentioned that scholars can obtain a state-of-the-art understanding by reading bibliographies, meta-analyses, and high-quality literature review articles. Furthermore, a thorough literature review helps document the progress of a discipline and update the academic community. By contrast, it can enable researchers to become more efficient and effective (Kraus et al., 2021).

Since the research study seeks to understand the journey of tech startups through the lens of entrepreneurial pivoting and the influence of technology maturity, the project is focused on understanding three primary phenomena i.e., a) technology startups and entrepreneurs, b) how startups survive in a do or die situation, c) the impact of technology maturity. Therefore, this chapter focuses on the literature review of five related concepts: technology entrepreneurship (TE), the Lean Startup Approach (LSA), the technology S-curve, technology readiness levels (TRL) and leadership styles.

2.2 Technology Entrepreneurship (TE)

Technology entrepreneurship is a well-known theory in academic research. However, numerous potential combinations of entrepreneurship and technology have resulted in multiple variations in technology entrepreneurship. A few such examples are corporate technology entrepreneurship (Gracia-Morales et al., 2014) as well as digital entrepreneurship and digital technology entrepreneurship (Goines and Brem, 2017). Various researchers have defined technology entrepreneurship as gathering resources and technical support to convert an opportunity into value. For example, Spiegel and Marxt (2011) explained how entrepreneurs assemble resources, technical systems, and strategies to pursue opportunities. Bailetti (2012) described technology entrepreneurship as a combination of technical individuals and deploying heterogeneous assets associated with scientific and technological knowledge to create and capture value for a startup. Whereas Ferreira et al., (2016) explained technology entrepreneurship as a combination of entrepreneurship and technology-based innovation. Similarly, Beckman et al., (2012) illustrated technology entrepreneurship as exploiting opportunities associated with advancements in science and engineering. Conversely, the mission of tech entrepreneurs is to create a market/opportunity/value through finding an application using new or existing technologies (Giones et al., 2013).

Studies by Fryges and Wright (2014) and Mosey et al. (2017) identified that technology entrepreneurship research had gained attention due to technology commercialisation efforts by new tech startups, including university spin-off companies. However, researchers have pointed out that the digitisation of technology and digital technology are different. For example, digital entrepreneurship is defined as a firm developing its products or services based on the internet (Nambisan, 2017). Digital technology entrepreneurship can be explained as a startup developing its products using information and communication technology (ICT) systems (Giones and Brem, 2017).

Zahra (1993) as well as Tushman and Anderson (2004) defined technology entrepreneurship as a branch of entrepreneurship that considers technological innovations. Jones-Evans (1995) further defined technology entrepreneurship as creating a new technology venture. Similarly, The Canadian Academy of Engineering (1998) described technology entrepreneurship as innovatively applying the scientific knowledge by individuals who operate an enterprise (Kilintzis et al., 2022). Shane and Venkataraman (2003) characterised technology entrepreneurship as pursuing commercial opportunities by aggregating resources, technical systems and strategies. Whereas Dorf and Byers (2005) defined technology entrepreneurship as a business leadership style that recognises upcoming technology-intensive opportunities. Therefore, the tech entrepreneur gathers talent and capital to commercialise the opportunity.

According to Beckman et al. (2012a), technology entrepreneurship is the confluence between entrepreneurial opportunities and technological innovation. However, technology entrepreneurship is contingent on human and social capital (Pathak et al., 2013). More historically, Schumpeter (1942) explained that entrepreneurs develop market fit products by exploring new combinations of resources.

Over the past few decades, various industries have been trying to address the challenges of growth by introducing innovations through exploiting and commercialising new technologies. For any economy, technological advancement is one of the most critical aspects of economic growth. Technological Entrepreneurship (TE) can help explain how entrepreneurs assemble resources, technical systems, and strategies to pursue opportunities. There are two crucial phases in TE. The first phase is the assembly of resources and the technical systems. This phase is known as *"Formation"*. The formation phase also involves the recognition of opportunities. The second critical phase in TE is exploiting recognised opportunities, known as *"Exploitation"*. Researchers have also identified a third phase in TE, the *"Renewal"* phase

(Spiegel and Marxt, 2011). Figure 3 is a representation of the three phases of technology entrepreneurship.

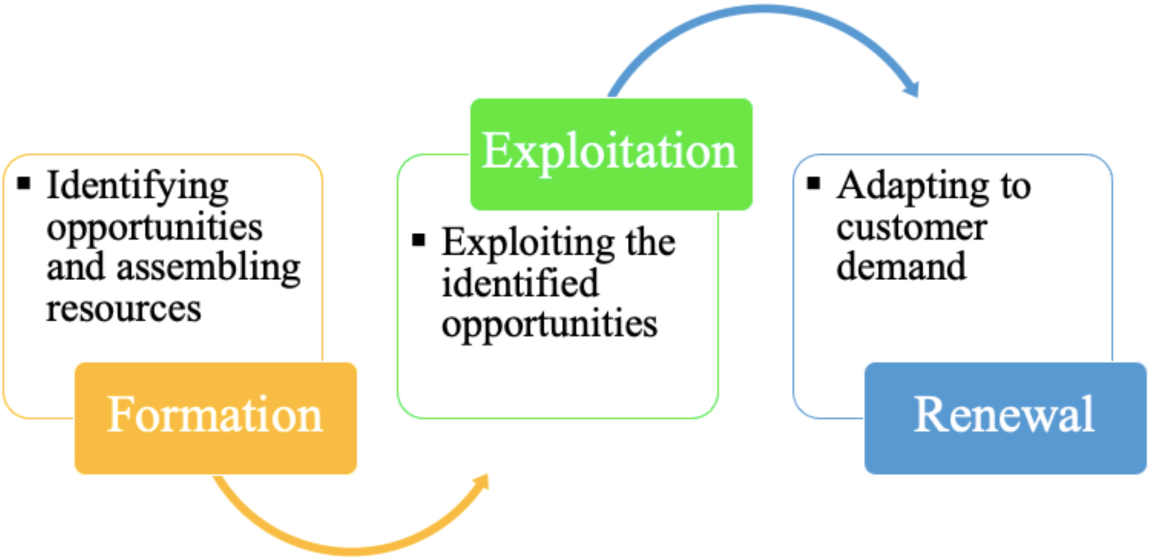

Figure 3. The three phases of technology entrepreneurship (Spiegel and Marxt, 2011).

Conversely, other researchers have a different point of view about varying levels of TE. They have argued that there can be many levels in TE. For example, Kilintzis et al. (2022) referred to technology entrepreneurship as a multilevel framework that operates on a wide range of individual, organisational, and systems-level factors, thereby building value through technology. Whereas Phan (2004) described three levels of TE: individual level, executive level and systems level. Entrepreneurs, scientists, and venture capitalists work to derive technological innovation focus at the individual level. Another level is the organisational level, where the research focuses on technical teams, processes, and other linkages between organisations that impact *"value creation"*. External factors like government policies, competitions, industrial standards, and the economy are considered at the system-level. Therefore, TE research involves multilevel analysis.

In his seminal research, Schumpeter stated that new firms are often responsible for disruptive innovations (Sood and Tellis, 2005; Schumpeter, 1939). However, large and existing firms have a relatively better chance of introducing *"incremental innovations"* that are enhanced than the existing technologies. So, both types of firms are vital for the commercialisation of technologies. Spiegel and Marxt also developed a new framework that includes new technology-based firms (NTBFs) and incumbent technology-based firms (ITBFs). This framework incorporates all the aspects of technology entrepreneurship associated with *the "formation, exploitation and renewal of products, services and processes in technology-oriented firms"* (Spiegel and Marxt, 2011). Figure 4 shows the elements of the TE framework.

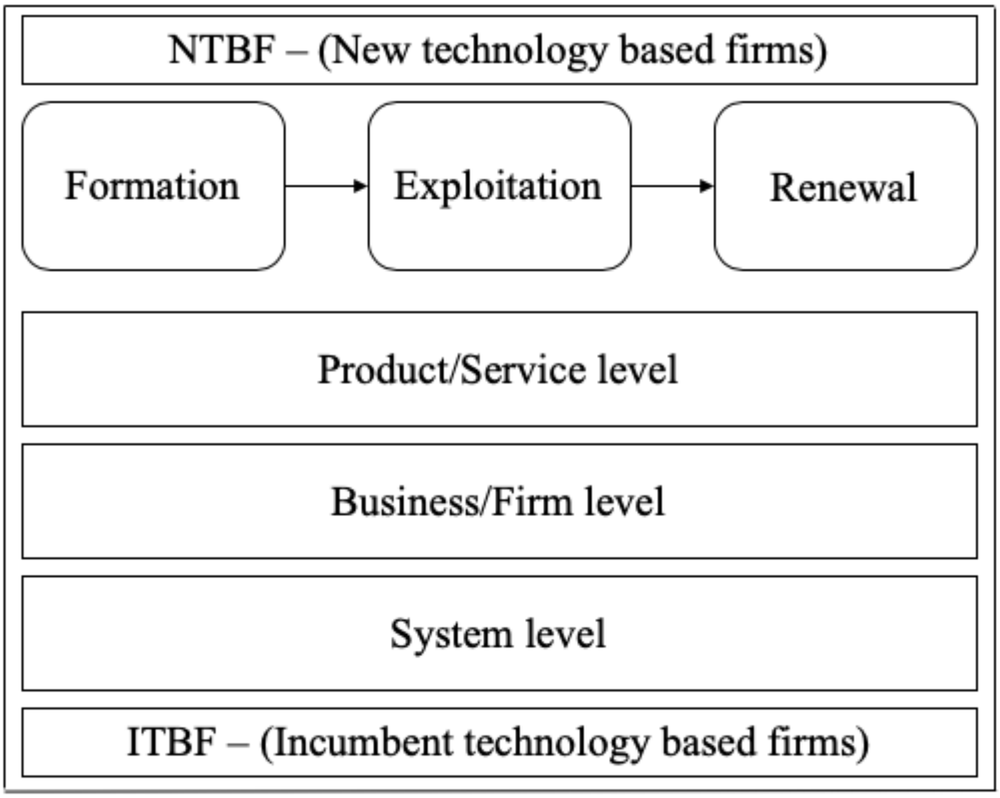

Figure 4. Elements of TE framework (Spiegel and Marxt, 2011).

Factors affecting technology entrepreneurship may primarily derive from the three primary levels: the product, firm, and systems level (Gupta et al., 2009). Factors include the tech entrepreneur's characteristics and abilities at the micro or individual level. For example, specific technological talents, business management skills, effective relationships with customers, venture capitalists and investors are primary technological personal capabilities. In addition, according to Nacu and Avasilcai (2014) and Nazarov et al. (2015), industry knowledge, ideas, originality, perseverance, trust, and perspective are also deemed vital traits of a tech entrepreneur. Furthermore, Fellnhofer and Puumalainen (2017) pointed out that the inspiration acquired from fellow entrepreneurs can enable distinct entrepreneurial identity and contributes to technology entrepreneurship enhancement. Similarly, Urbano et al. (2019) and Mosey et al. (2017) believe that entrepreneurial orientation is a fundamental personal attribute for all tech entrepreneurs.

A tech startup searches for new products, services, or even new corporate ventures in the formation phase. Consequently, a tech entrepreneur would be looking to address how the tech startup can find or develop a unique business opportunity. Therefore, at the formation phase in the product level, the plan is to identify new ways of innovation. At the business/firm level, the entrepreneur would focus on assembling organisational resources. For example, the role of the entrepreneurial team and source of funding/investments (Spiegel and Marxt, 2011). Thus, what type of business model should be adopted for the startup would be investigated. In the third level, i.e., systems-level, the tech startup considers the conditions for expansion and further development of the business. The overall context and situation include the general economy of the country, government regulations, policies on taxes, technology innovation, geographical location of the company, and whether the company is located in a technology and innovation ecosystem (such as Silicon Valley) or an incubator hub.

The second phase in technology entrepreneurship is the exploitation phase, which focuses on commercialising the ideas. Here tech entrepreneurs plan to identify how the startup can effectively commercialise the products or services. At the product or service level, tech entrepreneurs concentrate on the possibilities for developing new products or services and look for optimal customer segments. At the business/firm level, the question tech entrepreneurs try to address is how to create circumstances where the tech startup can sustain itself in the ever-changing environment. Finally, at the third level (systems level), a tech startup concentrates on using what type of technology can be utilised or how technology transfer can be achieved successfully (Spiegel and Marxt, 2011).

Spiegel and Marxt (2011) previously explained that in the final phase of technology entrepreneurship (i.e., renewal phase), the tech entrepreneur focuses on adapting to customer demands, and the firm will renew its product or service. The reasons behind the tech startup's renewal are changing customer demands, introducing new technology, or external factors such as the global market crisis, competition, and government regulations. In addition, the tech startup will be concentrating on identifying new ways to adapt to the abovementioned situations. Therefore, the questions that need to be addressed at the product or service level in the renewal phase are how the tech startup can adopt new technologies to support its product or service portfolio. During this phase, the tech entrepreneur will also consider the product and technology life cycles. For example, tech startups consider the technology life-cycle stage to understand in more detail the potential future developments of the technology. At the business or firm level, tech startups focus on identifying new strategic pathways for the company and how to adjust to such new opportunities. By contrast, at the systems level, the focus is on extending the technological limitations, identifying the function of ethics in technology, and understanding how effective the innovation initiatives are (Spiegel and Marxt, 2011).

2.3 Lean Startup Approach (LSA)

The Lean Startup Approach (LSA) is a hypothesis-focused model, where an entrepreneur assesses an opportunity. Ries (2011) defines the LSA in his book *The Lean Startup*: The translation of an entrepreneur's vision into a falsifiable hypothesis, which is usually a solution for the customer's requirement. Then the hypothesis is tested using a sequence of product prototypes that are intended to support the business model specifications, or the product features meticulously. The uniqueness of this approach is its ability to consider various uncertainties in terms of appropriateness of the solution regarding customer problem. Blank (2003) initially explained the lean startup method in the customer development model (CDM). Ries (2011) later expanded this by explaining several vital parameters of the build measure learn (BML) principle. Furthermore, these two organisational frameworks were supplemented by the business model canvas (BMC) to form a conceptual background known as the lean startup methodology (cited in Tanev et al. 2015).

The lean startup approach has gained popularity as a customer-centric, learning and finding process rather than a product development model. Blank (2013) and Ries (2011) pointed out two important aspects of the lean startup approach. Blank mentioned that the lean startup approach is a transitory design by an organisation in search of a business model which is scalable and repeatable. Whereas Ries stated that the "*lean startup is a human institution designed to build new products and services under extreme uncertainty conditions*". The meaning of lean in the lean startup approach is associated with traditional lean manufacturing theory. The concept states that the most significant waste for any startup is producing a product or a service that no one requires. The lean startup approach focuses on minimising expenditure in the early stage of the business and creating value for customers. Consequently, the LSA focuses on experimentation on the product through gaining customer inputs in the form of feedback and redesigning. This experimentation on products leads to a concept called the minimum viable product (MVP). The MVP is a product that consists of a minimum set of features in order to reduce the wastage of engineering hours and place it in the hands of initial and far-sighted customers as soon as possible (cited in Tanev et al., 2015, p. 9).

Tanev et al. (2015) mentioned that Eric Ries identified the vital principles of the Lean Startup Approach. According to Ries (2011), one can be an entrepreneur and initiate a startup anywhere. Entrepreneurship is dependent on management in certain aspects, and a startup is an institution and not a product. Therefore, entrepreneurship needs a new class of management which is explicitly prepared for a specific context. The Lean Startup Approach is associated with the method of substantiated learning. In this regard, startups exist to learn and build a sustainable business and not simply to create a product or service and make money. A startup also requires a new form of accounting for quantifying progress, setting milestones, and prioritising tasks. The Lean Startup Approach helps in achieving above mentioned specifics by adoption of BML process, which comprises of converting ideas into products or services by evaluating customers responses, and then to understand whether to pivot or persevere (Tanev et al., 2015).

Eric Ries, who is an entrepreneur and author of "*The Lean Startup*", defined a startup as a human institution intended to design new products and services under conditions of uncertainty. Moreover, Ries explained that the productivity of startups is not just about developing new features but is also concerned with aligning all efforts to create and sustain the value proposition. Conversely, Guo et al. (2021), Kirchberger et al. (2020) and Wouters et al. (2018) explained the value proposition as a value that a firm intends to offer to its customers, which in turn explains why customers will prefer one company's product or service. Authors like Blank (2013), Ries (2011), Osterwalder and Pigneur (2010) are some of the key contributors to the Lean Startup Approach (Shepherd and Gruber, 2021). The word lean is often misconstrued as a startup adopting a bootstrapping business model, i.e., keeping its cost as low as possible and relying on the founder's resources. Instead, lean startup adopts the same objective of lean manufacturing, i.e., avoiding waste (Eisenmann et al., 2012). The lean startup approach is the implementation of lean thinking into the process of innovation and startup's activity. It is believed that the foundation of Toyota's success can be utilised to enhance the rate at which startups can find validated learning. The approach argues that implementation of lean will lead to a successful business and startups (Felin et al., 2020). The Lean Startup Approach (LSA) introduced two concepts, namely the Minimum Viable Product (MVP) and pivoting. Developing a version of product/service and releasing it to learn about customers with the least effort is known as MVP. Indeed, a study conducted on 227 digital startups in Italy to understand how they adapted and implemented the LSA found that the approach is a set of an operational, systematic, and scientific decision-making tool for entrepreneurs as it helps in creating opportunities (Ghezzi, 2019).

The primary goal of a startup is to find a viable business model that can create value for its customers, and the lean startup approach is a process to validate business models according to being agile and iterative. Similar to the case of entrepreneurship, the startup does not have a universally accepted definition. Ries (2011) explained a startup as an institution which operates under highly uncertain conditions to develop new products or service. By contrast, Blank (2020) explained that a startup's primary goal should be to find a scalable business model that can be used repeatedly. A business model relates to how a firm is economically and financially sustainable while creating and delivering value to its customers. Many scholars believe that startups do not have a feasible business model in the early phases to achieve the company's long-term objectives and it is rare for startups to develop an ideal business model at the early stages (cited in Bortolini et al., 2018).

The lean startup approach is a hypothesis-focused approach, where an entrepreneur assesses an opportunity according to an underlying assumption, or hypothesis. Ries (2011) defines this concept in his book *The Lean Startup*. The hypothesis is tested using a sequence of product prototypes that are intended to support the business model specifications (or product features) meticulously. The uniqueness of this methodology is its ability to consider various uncertainties in terms of appropriateness of the solution regarding the customer problem. Blank (2020) explained the link between the lean manufacturing method and the customer development model (CDM). Ries (2011) later extended this view by explaining several vital parameters of the build measure learn (BML) principle. Furthermore, the lean global startup (LGS) has been developed to emphasize the challenges for new technology startups to effectively deal with the need for business development and innovation as well as internationalization (Tanev *et al.*, 2015).

Harms and Schwery (2020) explained that an entrepreneur may learn from a variety of individuals, such as mentors, venture capitalists and fellow entrepreneurs. However, interacting with customers is the best option to understand what they want and need. The traditional approach for new product development rarely asks for inputs from customer and this makes entrepreneurs learn the hard way about what customers do not want. The simplest way of understanding customer requirements is by engaging them with the product/service. LSA proposes variants of the business model canvas, quantitative and qualitative market research, and rapid prototyping (via the MVP) to support the exploration of opportunities that helps entrepreneurs avoid costly errors and enhance the probability of success.

The LSA focuses on minimizing expenditure in the early stage of the business through creating value for customers. Consequently, it concentrates on experimentation on the product with customer inputs in the form of feedback and redesigning the product or service as required. This experimentation on the product leads to a concept called the minimum viable product (MVP). This is a product which consists of a minimum set of features to reduce the wastage of engineering hours and to place it in the hands of initial and far-sighted customers as soon as possible (Tanev et al., 2015).

According to Ghezzi and Cavallo (2020), the five principles of lean are identifying value, creating a process flow, eliminating excess engineering hours, producing a high-quality product, and creating value for customers. The lean startup approach is an opportunity exploration method, and entrepreneurs use it to develop a validated business model to sustain and scale up their business. This approach emphasises how entrepreneurs achieve deeper customer needs and design new hypotheses to develop a market-fit product (Harms and Schwery, 2020).

The lean startup approach emphasizes the challenges faced by tech startups (Tanev et al., 2015). To sustain the competition, the startups and the large companies have moved from the traditional ways of business management such as cost efficiency, quality improvement and reduction in time to develop the product (Rejeb et al., 2008). An increase in the awareness of the Lean Startup Approach has helped software companies to grow rapidly in recent years. Practitioners have promoted widely the concepts of the Lean Startup in the early days. However, researchers from academic communities have shown more interest in understanding and promoting the Lean Startup approach (Unterkalmsteiner et al., 2016). Although the lean startup approach is developed for startups, a survey conducted on 170 corporate executives by Kirsner (2016) revealed that 82% of participants are using lean startup concepts. Ries (2011) mentioned that large companies can also adopt the underlying principles of Lean Startup. The Lean Startup approach has gained popularity among the partitioners and the research community because it is pursued as a new way of entrepreneurship. The concept can potentially innovate products during extreme circumstances where the problem and solution are unknown. One of the principles in the Lean Startup is re-iteration of the product while delivering it.

2.3.1 Entrepreneurial pivoting

A research study by Hirikoski (2014) mentioned that due to resource scarcity or market conditions, in the early phases of a tech startup, such as the inception phase, startup phase or survival phase, companies often undergo frequent changes in their business model applying the LSA. In such a case, the entrepreneur would choose a new path, i.e., change direction, or pivot for creating value. Those decisions turn into key juncture points (or pivots), where companies or startups change their strategy or product or the whole company. Continuous innovation develops new ideas, products and helps to renew organizational structures, which is acknowledged as long-term growth. Most startups decide to pivot because the idea is not practical, or customers are not scaling up. In addition, it can be observed that classic examples of pivoting were carried out by tech companies such as Nokia, Facebook, and Twitter as they changed and adapted business models over time. The decision to pivot involves managing uncertainty as it may potentially jeopardise the firm's survivability. Due to this uncertainty, researchers have identified that it is challenging to determine what, when and how to pursue a pivot (Flechas Chaparro and de Vasconcelos Gomes, 2021).

Hirvikoski (2014) described that a startup comprises a group of talented people who try seizing an opportunity and enter into the market by capitalising their ideas. In most of the entrepreneurial journeys, there will be a situation when the startup would choose a new path (i.e., pivot) for creating value. Those decisions turn into key pivots, where companies or startups change their strategy or product or the whole company. Furthermore, continuous innovation will develop new ideas, products and helps to renew organisational structures, which is acknowledged as long-term growth. Most startups decide to pivot because the idea is not practical, or customers are not scaling up. These moments further build or discontinue a startup.

The second insight, perhaps, is that the underlying logic of LSA is to 'fail fast, fail cheaply'. The third insight is the heterogeneity in pivots. Pivots are performed for value creation, value delivery, or both, and further research is needed to explore the need for specific pivots for these purposes. The final insight is the concept of the runway. During times of uncertainty, the entrepreneur measures the runway time left for their startup. A runway time is a remaining time in which a startup must find how to lift off before it exhausts its financial resources, or it will fail. One of the ways to measure the runway is how many pivots (i.e., number of opportunities) a startup must change its original hypothesis to sustain and succeed (Ries, 2011).

Ries (2016) characterised pivoting as a change in the strategy without changing a startup's vision. An entrepreneur's vision is the long-term direction of a startup that remains unchanged. At the same time, the strategy to achieve long-term goals is expected to change with a series of pivots (cited in Contigiani and Levinthal, 2019). Pivots help in achieving the desired results for tech startups. After pivoting, several examples of tech startups became market leaders in their respective industries. For example, Twitter, which started as Odeo, pivoted from a podcasting company to a social networking company. YouTube pivoted from a video dating site to a video hosting site. PayPal pivoted during its early stage while establishing itself as a business for exchanging money (Haden, 2017).

Researchers such as Brenk et al. (2019) described that a pivot means a change in strategy by a startup. Moreover, Axelson and Bjurström (2019) explained the pivot as a change in approach towards an idea. Teece (2018) defined the pivot as a substitution of the existing business model, whereas Shepherd and Gruber (2020) called it an organised way of rectification to test new hypotheses. However, the pivot was defined initially by Ries (2011, p. 149) in his book *The Lean Startup* as a "*structured course correction designed to test a new fundamental hypothesis about the product, strategy, and engine of growth*."

Devece et al. (2016) described pivoting as proof of a fundamentally more suitable entrepreneurial opportunity that the firm is capable of exploiting. Therefore, only certain entrepreneurial efforts would qualify as a significant pivot. Furthermore, the literature on entrepreneurship differentiates entrepreneurial initiatives as 'being necessity' and 'opportunity driven'. In comparison, necessity-based entrepreneurial initiatives require a significant share of individual efforts, which rarely allow the enterprise to conduct fundamental testing – a crucial feature of pivoting. By contrast, opportunity-based initiatives seem more favourable in this regard.

Pivoting may be valuable, and there are examples of businesses successfully repositioning themselves to address exogenous shocks. Nevertheless, not every change is a pivot, and fundamental changes that occur in response to pivoting come at an expense. For example, the newly uncovered opportunity may be of inferior quality for the enterprise as it may or may not be sustainable in the future. While pursuing such opportunities, the firm may encounter survivability issues. Moreover, the process of pivoting itself may be challenging for the firm (Molly et al., 2010).

Berends et al. (2021) conducted a study with five ventures to understand when entrepreneurs decided to pivot or persevere. Given the uncertainties surrounding startups, entrepreneurs potentially encounter unanticipated circumstances while pursuing establishment of their venture. On experiencing such events, entrepreneurs may decide to persevere or pivot. In their study, they explained temporal and relational commitments. Relational commitments are those that entrepreneurs make with stakeholders and the identities they develop. In comparison, temporal commitments are the timelines and milestones a startup has set for itself. Since temporal commitments are linked to relational commitments, entrepreneurs must address both to decide whether to pivot or persevere.

To persevere, entrepreneurs adjust their temporal commitments to ensure their efforts are placed as a continuance of the past. Such positioning enables entrepreneurs to hold their earlier relational commitments by extending the timelines of activities and targets. Therefore, by adjusting temporal commitments, entrepreneurs persevere and avoid disruption in their relational responsibilities. In the case of pivoting, entrepreneurs reposition the startup's actions by revising the timeline to align with a new project's future. Notably, entrepreneurs reduce the time commitments of actions and milestones anticipated and facilitated change in relational commitments to perform pivoting (Berends et al., 2021).

Researchers have previously defined pivoting as a "*structural course of correction*" (Ries, 2011, p. 149). Some researchers, such as Hampel et al. (2019) as well as McDonald and Gao (2019), explained pivoting as a "*radical type of organisational change or a strategic reorientation*" (cited in Kirtley and O'Mahony, 2020, p. 199). However, Kirtley and O'Mahony (2020) defined a pivot as a shift in a company's strategy that aligns with the business's strategic direction through reorganising actions and resources. Additionally, researchers described how startups that predict, implement, and justify pivot(s) are more likely to gain support from external audiences than those that do not pursue pivoting practices. Conversely, startups that develop user communities and deeply identify with the enterprise can be threatened by a pivot. According to Ries (2011), pivots are perceived as a standard norm for startups (Ries, 2011). In contrast, the study by Kirtley and O'Mahony (2020) revealed that only three out of seven firms in the sample participated in a single pivot, although this appears to be a relatively small sample for a research study. When a startup changes its strategy, it chooses a strategic exit to address a problem or strategic orientation to benefit from an emerging opportunity instead of completely reorienting the current strategic approach with one decision. Furthermore, it has been reported that startups that pivoted made numerous incremental decisions that led to a strategic reorientation over a period rather than changing the strategic direction with a single pivot (Kirtley and O'Mahony, 2020).

Sadeghiani et al. (2021) compared five small and medium enterprises to conceptualize the pivoting process, where they emphasised how different researchers theorised pivoting as part of the study. For example, Leatherbee and Katila (2017) described the refinement of the business model as pivoting. Boddington and Kavadias (2018) positioned it as an evolutionary search process and as an organisational learning process. Conversely, Grimes (2018) explained a pivot as a creative revision of an entrepreneur's identity. Finally, Camuffo et al. (2020) presented pivoting as a scientific decision-making process involving significant transformations in the business value propositions or target consumers (cited in Sadeghiani et al., 2021). Moreover, a study by Pillai et al. (2020) emphasised strategic pivots that need irreversible firm commitments. The study's analysis illustrated that strategic pivots are associated with success. Furthermore, their study described strategic pivoting as a subset of economic experimentation because successful firms validate their strategies through economic experimentation.

The study by Sadeghiani et al. (2021) does not solely focus on tech-related enterprises. Instead, their study focused on how pivoting changed small businesses in Iran to show that the phenomenon exists and is not limited to fast-track or technology-based startups. The five test cases were as follows 1) Mehri, daughter of the late Amoo-Mossa, who owns Ice cream Town in Khuzestan, Iran; 2) Ayat, who has a micro business and experience in several other businesses throughout his career in Iran; 3) Soheila, an informal micropreneur; 4) Abo-Ali, who runs a falafel business in Lashkarabad and 5) Neshat Tabbakhi restaurant's owner.

In this study, Sadeghiani et al. (2021, p. 11) explained that the "*pivot could not be reduced to a construct for deductive positivistic research to test or elaborate theory*". Pivots can be successful or unsuccessful. In the case of small and micro-business, successful pivots can lead to sustained business or more financial yields, but some small businesses stay small. In the study, pivot triggers were categorised into three categories, namely a) failures, b) feedback from stakeholders on business and c) data on new opportunities.

The design of a business model is crucial for any startup. Most executives believe that successful enterprises have built their success on business model innovation. However, the business model design often stays underdeveloped and is poorly understood. This uncertainty is particularly challenging for innovation-based startups, where a viable business model must be designed from the foundation. This is because the entrepreneurs are often experts in the technical dimension of the innovation adopted by the venture and may not be specialists in business design or management. Just as entrepreneurs use the Business Model Canvas for designing business models, Garcia-Gutierrez and Martinez-Borreguero (2016) developed the Innovation Pivot Framework for entrepreneurs to conduct strategic analysis. This framework consists of four steps, each represented in a diamond-shaped form that describes their interrelatedness. For example, the first step is the "*Innovation object*", defined as the idea guiding the startup. The second step is called "*Impact*", the value created by the startup for its stakeholders. The next step is "*Uncertainty*", where there is potential for growth as well as the risk of failure. The last step is "*Sustainable competitive advantage*", where the long-term competitive edge emerges due to the last three steps (Garcia-Gutierrez and Martinez-Borreguero, 2016). Furthermore, each of these four steps are divided into two sub-areas. For instance, the innovation object is sub-divided into invention object and problem solved. The impact is divided into impact on stakeholders and monetisation strategy. Similarly, uncertainty is divided into uncertainty mapping and risk management. The framework's last step, sustainable competitive advantage, is divided into an innovative core competency and business model innovation (Garcia-Gutierrez and Martinez-Borreguero, 2016).

Another study on pivots by Hampel et al. (2020, p. 5) focused on understanding how entrepreneurs maintain relationships with stakeholders after pivoting. The study described that startups could associate with stakeholders during pivots by engaging in identification reset work. For example, there are two strategies that startups can enact when ties with stakeholders who initially recognized them break down: 1) "*seeking empathy for the venture's challenges*" and 2) "*mythologizing the technology and the venture's commitment to its products*". Through identification reset work, entrepreneurs can overcome their issues with stakeholders by disclosing the startup's struggles and efforts in addressing them. In addition, it allows the entrepreneurs to show the virtue of their motives and the uncertainty that has caused them to deviate from the original plan. Therefore, forming an emotional narrative with stakeholders.

Previously, entrepreneurship has been viewed as adopting a business planning paradigm beginning with developing a blueprint for the startup, securing investments, and executing the plans. However, new ventures operating in dynamic environments have increasingly challenged this approach. As a result, a new paradigm called the Lean Startup has gained popularity in recent decades, where entrepreneurs highlight the investigation of new ideas through constant testing and collecting customer responses to address competitive threats or changes in consumer preferences (Ries, 2011). Pivoting is a crucial component of this new paradigm and has gained much interest from incubators, ventures, and business programs in universities worldwide (Hampel et al., 2020). A recent study by Grimes (2018) is an exception. The study examined the creative revision process practised by entrepreneurs as they pivot to a new startup idea. The study indicated that entrepreneurs must overcome emotional resistance to the original idea and pursue pivots —especially entrepreneurs whose startup exists in the early establishment stage.

Bajwa et al. (2017) extended research on types of pivot and factors affecting the pivots, using Ries's (2011) theory on pivots. They conducted a case study on software startups. Software startups, which operate under changing and unpredictable circumstances need to have a viable and scalable business model. According to Giardino (2015), one of the challenges that a software startup faces is to thrive under technological indecisiveness Whereas Bohn and Kundisch (2018) conducted research, which focused only on the technology pivot, to understand the antecedents and consequences of using the technology pivot under beneficial circumstances. In their study, fourteen software startups, which used business-to-customer (B2C) and business-to-business (B2B) business models, were analysed. The empirical research identified five categories of antecedents of the technology pivot; three prerequisites for the technology pivot; and nine categories of distinctive consequences. The three categories of antecedents were increasing system performance, increasing future architectural viability, and increasing system maintainability, which related to the technology. The remaining two categories were related to financial or strategic management. The participants in the research revealed that desirability, feasibility, and viability are the prerequisites that need to be fulfilled to exercise technology pivots. The authors concluded that failing to recognise the right time to pivot and the right reasons can considerably endanger startup success (Bohn et al., 2018).

To understand how software startups develop their business and how well they perform after pivoting, case study-based research was conducted by Terho et al. (2015). Three software startups from the Tampere region in Finland were chosen for this study. The three companies were Illegal Alien Studios (IAS), Tapila, and Movendo, which were all founded in 2013. People who were involved in the startup were interviewed to understand the concept of pivoting from their perspective. The study included unstructured interviews based on the lean startup approach. The interviews focused on understanding the initial and current situation of the company. In the study, it was identified that startups had implemented several types of pivots. Some pivots triggered startups to further pivoting, like a domino effect (Terho et al., 2015). IAS is a mobile software development company and after releasing their first product, the market situation had changed for the company. As the customer segment was unclear for the startup, issues emerged and therefore they decided to change the monetisation model. Thus, IAS wanted to establish a close relationship with customers. The study identified a total of five pivots. The first three pivots (a business architecture pivot, a customer segment pivot, and a channel pivot) occurred when the startup tried to shift from an Appstore business model to a B2B model. Once IAS implemented these pivots, the startup has seen a radical difference in terms of handling problems, customer segment and channels. Later, when the startup changed its working platform from Windows to Android, it opted for a platform pivot. After implementing this pivot, IAS faced a new challenge in terms of resources, knowledge, and skills as they were shifting from one platform to another. As the project advanced, IAS carried out the fifth pivot (a so-called zoom-out pivot) to include additional features in the product after this pivot, and this helped IAS to attain a more significant role in the project they were working on (Terho et al., 2015).

The second company was Tapila, which started to address a problem with logging hours using a mobile application. The monetisation model for this startup was from gaining payments for a customisation fee and subscription fee. Later a construction company approached Tapila for the product with additional features. Due to increased workload, a business decision was taken by the startup not to improve the product, but to roll out the product to a different industry, and they subsequently shifted their focus to gym clients. Therefore, they implemented a customer segment pivot and a zoom-out pivot to shift their business from software development to a product-based business. After that, Tapila opted for a business architecture pivot and zoom-out pivot to expand into the construction business. Later, when they faced a downturn in the construction sector, they opted for a zoom-in pivot in order to re-enter the gym sector (Terho et al., 2015).

The third company is Movendos, whose focus was to create tools for health and wellness coaching. The original business model for the startup was to develop a mobile application for a single company and its monetisation model was a subscription fee. After the launch of their first product, the startup made a business decision to move from a mobile-based application to a web-based portal. The technology on which there were working on was not scalable to enhance the startup's business. Therefore, Movendos pivoted three times. Initially, the zoom-in pivot was carried out when the company was struggling to finalise the features for their first product. After that, the zoom-out pivot was done in order to scale up to the target customer base. Finally, the technology pivot was carried out when they decided to move from Android to SQL (Terho et al., 2015). An empirical study conducted by Bohn et al. (2018) reports that entrepreneurs should recognise the right time and the right reasons to pivot in order to have success. Failing to do so can significantly jeopardise the success of the startup. From the study of Terho et al. (2015) it is understood that all three startups, namely IAS, Tapila and Movendos opted to pivot in order to develop their business. After pivoting, the three startups attained more momentum in their business. The pivots carried out by the three startups were in each case to generate more revenue for the respective companies and make product improvements, which leads to the value proposition for customers.

2.2.1.1 COVID-19 Pandemic and pivoting strategy by entrepreneurs

Morgan et al. (2020) described that exogenous shocks cause significant economic disruptions. For example, the COVID-19 pandemic rendered disjointed supply chains, logistics challenges, shortage or unavailability of crucial resources, price fluctuations and government restrictions. Moreover, it led to redesigning the working techniques for most firms. Previously in similar situations, firms pivoted to address the SARS pandemic in Asia. For instance, in China Alibaba started the online shopping platform and created a marketplace while increasing its wholesale and B2B e-commerce business. The COVID-19 pandemic has also seen several successful pivots by other companies, such as by Camp Gladiator, a fitness company started in 2008. The original business model of Camp Gladiator was conducting training sessions in public places. However, during the COVID-19 pandemic, the firm changed its strategy and conducted virtual workout sessions. This change in direction helped retain 97% of their customers and acquire new clients. Many examples indicate that pivoting during uncertainty allowed companies to take advantage of the new opportunities and develop a winning strategy. Nevertheless, new startups must exercise pivots with caution while responding to opportunities introduced due to exogenous shocks.

Similarly, Sudarmiatin et al. 2021 conducted a study in Indonesia to understand how Micro, Small and Medium Enterprises (MSMEs) survived using pivoting strategies under challenging circumstances such as those in the time of COVID-19. The study referred to the work of Bertog

(2009), which provides five alternative pivot strategies, which are as follows: 1) offer more, 2) offer less, 3) solve a new problem, 4) redefine the market and 5) update the business models. There was a total of ten MSMEs involved in the study, out of which seven MSMEs executed pivoting strategies. Those seven MSMEs consist of three batik businesses, one marble business, and the remaining three food businesses. Meanwhile, the rest of the MSMEs felt that the most compelling marketing strategy is offline marketing such as word of mouth despite the significant sales decline. The pivot strategy used by several MSMEs in the Tulungagung district of Indonesia includes:

1. Conducting business in the offline and online market.
2. Boosting advertisements through different media.
3. Recruiting more resources for online marketing and participating in various digital marketing training.

2.2.1.2 Types of pivots

The concept of pivoting (change in direction) has gained the attention of many practitioners and tech startups, but the conceptualisation of different types of pivots and factors associated with this still requires further empirical investigation and validation (Bohn and Kundisch, 2020; Hampel et al., 2020). Indeed, Ries (2011), Hirvikoski (2014) and Bajwa et al. (2017) identified different types of pivots to test the hypothesis of a company (see Figure 5). In the research study, the pivots have been grouped into the following categories: a) product; b) market; c) strategy; d) team level pivots. In this context, terms like startups, entrepreneurs or companies are used interchangeably. In order to illustrate the types of pivots, examples of such pivots have been identified from a range of business websites, such as *The Washington Post*, *Medium*, *Digital Risks*, *TechCrunch*, and *Forbes*. Examples for market segment pivot, the engine of growth pivot and social pivot could not be identified from the LSA literature.

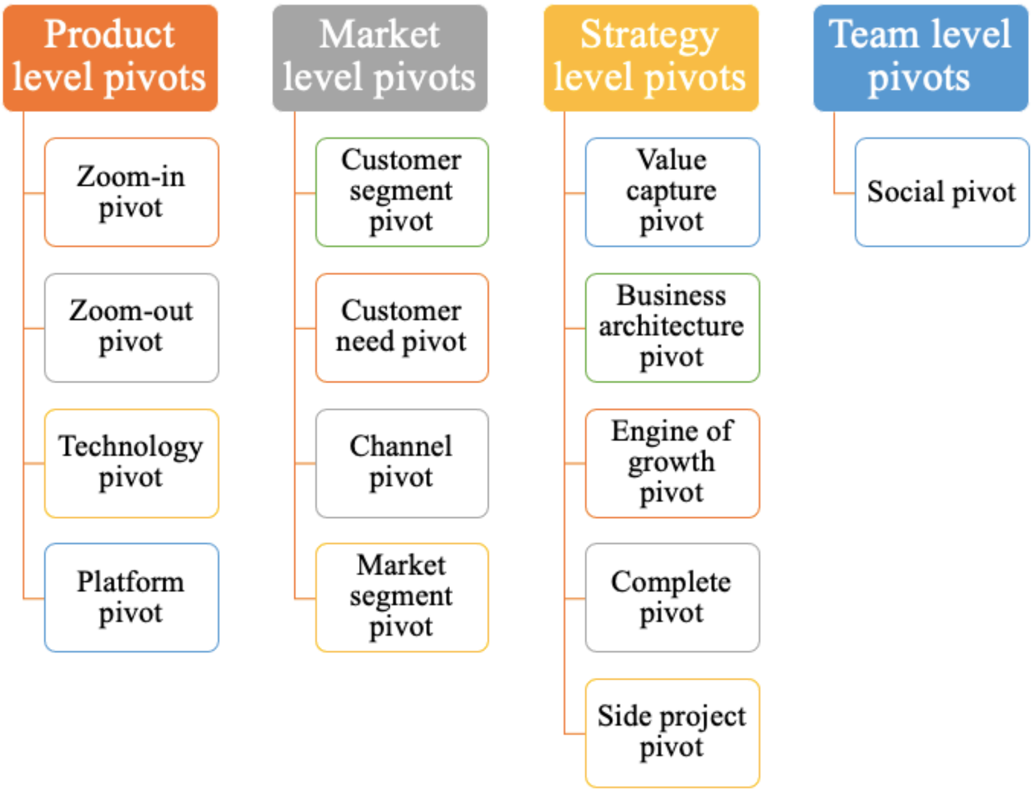

Figure 5. Types of pivots (Ries, 2011; Bajwa et al., 2017; Hirvikoski, 2014).

a) Product level pivots:

1) Zoom-in pivot: A single feature of the product that attracts the most customer base and the feature itself becomes the product (Ries, 2011). For example, Instagram – It was once known as Burbn. It was a check-in app in an online game called Mafia Wars. The creators felt that the app was too cluttered, so they removed all the features except one and, i.e., photos.

2) Zoom-out pivot: This type of pivot is the *vice versa* of the zoom-in pivot, where the entire product becomes a single feature of a much broader product (Ries, 2011). For example, Starbucks – In 1971, they started selling espresso machines and coffee beans. However, in 1983, Howard Schultz redefined it as a coffee shop.

3) Technology pivot: Every company will try to optimize their resources and provide the best possible solution for customers. This can be done by using different technologies

to address the same solution (Ries, 2011). For example, Netflix – Started as a mail-ordered DVD service. Due to growing download facilities of the movie, they moved to an online streaming service.

4) Platform pivot: One of the most used pivots in software industries is the platform pivot. Companies develop applications for their platforms, but sometimes the platform itself becomes a product for customers or clients (Ries, 2011). For example, Android – This startup was founded in 2003 and later acquired by Google in 2005. However, at the initial stage, Android was an operating system for cameras.

b) Market level pivots:

5) Customer segment pivot: A startup develops a product or a service targeting a customer segment. However, when they evaluate their product performance in terms of reaching out to the target customer base, the startup may find that although the product is attracting the customer, they are not the actual targeted customer. This means the startup needs to reposition its product or service and optimize according to that segment of the market (Ries, 2011). For example, Facebook – Mark Zuckerberg launched Facebook in 2004. The previous version of Facebook was to rank Harvard students based on their attractiveness. Eventually, Facebook extended to everyone in 2006.
6) Customer need pivot: A startup tries to commercialize an idea by addressing customer needs. However, the product or service idea may not necessarily be the most critical need of the customer. The startup will, therefore, pivot in order to meet an essential need of the customers (Ries, 2011). For example, YouTube – YouTube was started as a video-based dating site. The founders later realised that users had a better idea with what to do. So, they pivoted.
7) Channel pivot: Companies engage with customers through relevant channels to sell their products and services. Sometimes companies try to sell products directly to customers

and sometimes they may choose other channels as the route to market. A channel pivot is a basic solution for any company to reach out to customers in an effective way (Ries, 2011). For example, Avon – Avon is a famous brand in beauty products. David H. McConnell was a book salesman and realised that his female customers were more interested in the perfume samples which came with the books. So, he recruited women to sell his perfumes as they can relate more to the product and sales could be increased.

8) Market segment pivot: Rather than focus on entering the whole market, a startup may concentrate on entering a particular market segment because they see the potential for the business to grow (Bajwa et al., 2017).

c) Strategy level pivots:

9) Value capture pivot: Companies will use this pivot to change the way they monetize their product. This change will impact the value captured by the product, business, and the engine of growth (Ries, 2011). For example, Western Union – The company was founded in 1851. It was an international telegraph network, which used to send 200 million telegrams at its peak. However, due to email, telephone and internet business was down. They pivoted into a money transfer company as they have an established network worldwide.
10) Engine of growth pivot: Companies try to speed up their growth rate, profitability, and customer base through changing the business model. There are three primary engines of growth which are viral, sticky, and paid growth models. The primary motivation for companies changing the engines of growth model is to grow at a faster rate (Ries, 2011).
11) Business architecture pivot: Moore (2007), an organizational theorist, defined two major business architectures, which are the high margin and low volume model and low margin and high-volume model (i.e., volume-based operations). The company that wants to pivot to any of the above business architectures can adopt any one of them at

a given time (Ries, 2011). For example, Airbnb – The first concept of Airbnb was to provide accommodation solution focused on conferences. However, the founders understood that it was not a sustainable model and changed the business model to travellers looking for cheap accommodation.

12) Complete pivot: A pivot can be used to change a product, strategy, or the market for the company. When a team decides to change in all three areas as well as the business model, it is called a complete pivot (Ries, 2011). For example, Twitter – It is considered as a legendary pivot in the history of social media. Twitter was known as Odeo. It started as a service, where customers were allowed to find and subscribe for podcasts. Founders understood that it is hard to survive in the competition with iTunes from Apple. So, the company pivoted to a microblogging service and named it Twitter.

13) Side project pivot: Many companies may commence a parallel project alongside the main project. However, sometimes the side project becomes the main project for the company and this type of pivot is called the side project pivot (Ries, 2011). For example, Groupon – Originally it was started as a fundraising site for social causes, and the company named it as The Point. Groupon was started as a side project and eventually became the prime business.

d) Team level pivots:

14) Social pivot: Social factors play a significant role in pivoting. These factors can be due to changes in people or the environment, such as working on existing idea by partnering with an entirely new team (Hirvikoski, 2014).

2.2.1.3 Factors that trigger pivots

Several factors trigger pivoting, and they can be divided into external and internal factors. External factors are those that are beyond the control of a startup. By contrast, factors triggered due to startup activities are called internal factors. Figure 6 illustrates the list of factors that trigger pivoting, and the following section describes each factor (Bajwa et al., 2017).

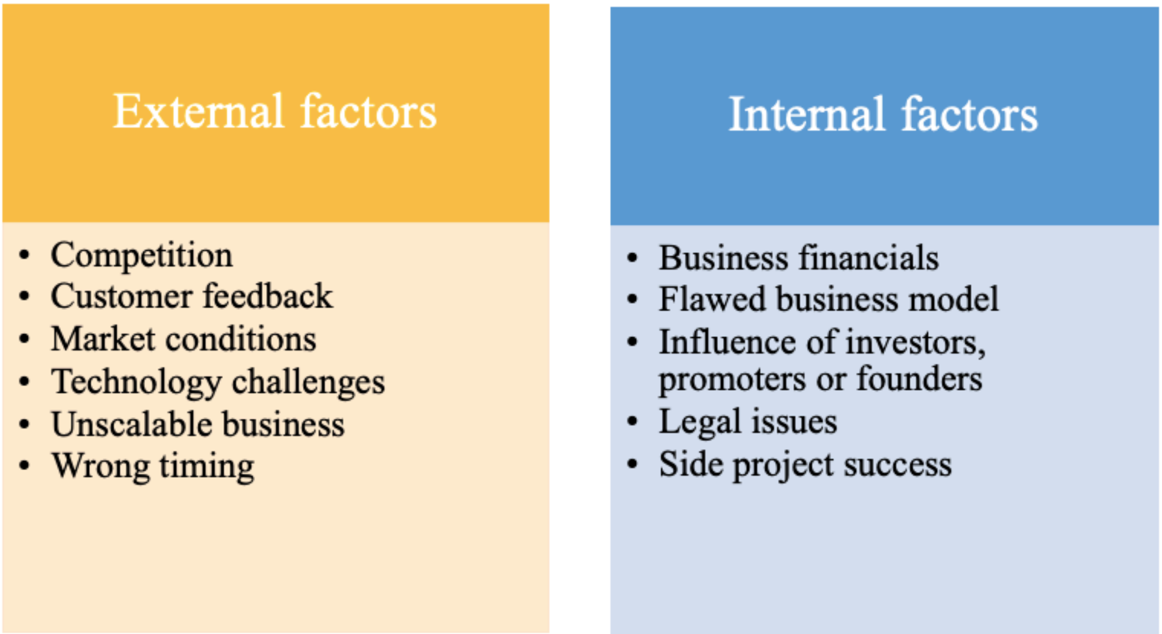

Figure 6. Factors that trigger pivots (Bajwa et al., 2017)

a) External factors

Adverse customer feedback about the product or service; and slow customer acquisition or retention lead to pivoting. When customers appreciate a feature rather than a complete product, a startup tends to concentrate more on that particular feature, which triggers a pivot. A startup enters the market with the product, but an unseen approach from customers makes them pivot. Sometimes startups try to provide a solution to the market and customers are not ready to accept that approach of product or service. So wrong timing leads to pivots. Furthermore, the positive response from the unanticipated customers may cause a need to change the focus of the startup to a new customer segment, which is a pivot (Bajwa et al. 2017).

Several incumbent firms, as well as other new startups, can execute an idea more effectively than the original startup, leading to failure of the startup to competition. Technology challenges such as limitations with the existing technologies or the new technology may need to address the bottlenecks and thereby trigger a pivot. In addition, an entrepreneur might have an idea for the startup, but an investor or partner or mentor influences them to change the direction of the business causing pivot (Bajwa et al. 2017).

A legal issue, like a patent or copyright violation, may create a disagreement between companies. As such, an entrepreneur tends to change the direction of the company accordingly. Another factor can be companies start a side project along with the main project. However, customers show more interest in the side project, which triggers a pivot. The substantially narrow market can also trigger for the pivot. If there is no longevity, there is no value for a startup as they cannot survive or grow in the future (Bajwa et al. 2017).

b) Internal factors

A flawed business model due to high incurred costs in generating revenue or high cost in retaining the existing customers as well as customer acquisition may lead to a pivot. Identifying new solutions to address the internal issues of the startup may also address the customer's needs. Another factor for pivoting is unscalable business, where a startup might address a problem, but the customer is not interested in the solution, which subsequently makes the business unscalable (Bajwa et al. 2017).

An entrepreneur is committed to exploring new opportunities. They face challenges in transforming those opportunities into a successful business. An entrepreneur should remain focused on their goals and not be discouraged due to setbacks. As such, entrepreneurs should exhibit strong commitments towards their ideas. However, because they are committed towards their initial ideas, this may actually hamper pursuing new opportunities (Crilly, 2018).

During commercialisation of the opportunities, entrepreneurs become an expert in the process associated with its technology, operations, and markets. High expertise in one segment may potentially make it difficult for entrepreneurs to shift to another direction. Thus, while exploring new opportunities, entrepreneurs collate lots of new information. This information may be related to the technology on which they are working, the targeted market segment, the competitors in that sector and other factors. Commitment towards one set of information and dismissal of other information-related data may blind the entrepreneurs to the possible risks of validating the idea (Crilly, 2018).

When an entrepreneur develops a business idea and explores a new opportunity, they will often be oriented towards the product on which they are working or the market which has accepted their product. With a high level of commitment and expertise, an entrepreneur may potentially fail to recognise the new opportunity or will show resistance towards a new opportunity because of product orientation or the market orientation (Crilly, 2018).

Sometimes, even though entrepreneurs want to pivot, they are restricted from attempting it because of resource constraints such as time, money, and people. Resources may be suitable for exploring one direction, which may limit the entrepreneur to looking for new opportunities. Change in direction may require a new set of resources, and exploring multiple directions may overly limit the availability of the resources (Crilly, 2018).

2.4 Technology Life Cycle

As mentioned earlier, the need to leverage technology is one of the fundamental challenges of a tech entrepreneur. Therefore, to leverage technology, the tech entrepreneur has to forecast the performance of the technology. Why is the forecasting of technology important? Any tech startup that can be affected by technological changes will essentially be engaging in technology forecasting (even though the company may not actually realise this). The continuous evolution of technology can set a tech startup towards a growth or decline path. Technology forecasting by a tech startup will help them in achieving the following objectives (Martino, 1993):

1. To have a competitive edge compared to other tech startups in the industry.

2. To forecast the capital planning in terms of investment in the technology.

3. To identify limits beyond which it is impossible to use the technology.

4. To identify an alternative technology that can perform better.

5. To develop a standard plan for the startup. Thus, a startup can compare its plan with a forecast to take further decisions.

Sood (2005) mentioned that standard terms like the industry life cycle, the product life cycle and the technology life cycle (TLC) are often used interchangeably, ambiguously and inappropriately. In the literature, the TLC is discussed as being based on two critical perspectives: the macro view and the S-curve (Taylor and Taylor, 2012).

2.4.1 The macro view of the technology life cycle

The macro view is concerned with technology evolution, its progression in industries, technology trajectories and the industrial evolution at the macro level. The model assimilates individual technology life cycles, which begins with a breakthrough innovation that affects the existing process or products, thereby causing technology discontinuity. Dan and Chieh (2009, p. 403) mentioned that some researchers explained this class of technologies that denote discontinuity, which is known as "*revolutionary, discontinuous, breakthrough, radical, emergent or step-function*". After such a breakthrough, technology follows a phase called a period of ferment. In this period, the technology is uncertain, and preferences of the potential users are unclear. Thus, competitors in the industry try to develop variations in the breakthrough technology. Eventually, the dominant variation in the original emergent technology becomes the single most dominant technology and an industrial standard (Murmann and Frenken, 2006). After the industry widely adopts the new emergent technology, a stage which is called an era of incremental change starts. During this stage, changes brought by the emergent technology are evolutionary and continuous. Once this stage is over, again, the stage of technology discontinuity begins and continues (cited in Taylor and Taylor, 2012).

2.4.2 The Technology S-curve

The history of the S-shaped curve derives from the eighteenth century. Since then, evolution has been considered a slow change initially and then proliferates in later stages and, in the end, slowly changes — scientists and researchers from different domains of knowledge discovered, reinvented and adopted various forms of non-linear curves. Therefore, the S-curve is also known as logistics curve, Foster's curve, Verhuslt-Pearl equation, Pearl curve and many more. Belgian mathematician Perrie Francois Verhuslt (1804-1849) derived the logistic equation to describe the 'self-limiting growth population'. Later the logistics equation was rediscovered by American zoologist Raymond Pearl (1879-1940). Since then, the S-curve has been used to study population dynamics and economic analysis. In the 1960s, the S-curve model and envelope curves were used to understand technological forecasting (Kucharavy and De Guio, 2011).

The progression of the technology at first advances slowly, followed by a rapid growth and then inevitable decline. Thus, conforming to a general form of an S-shaped curve. In the technical literature, the use of the technology S-curve is far more consistent (Taylor and Taylor, 2012.). Technology S-curves refers to technology improvements in a product or platform design over some time. Very often the technology S-curve is mapped with a performance next to time. The performance of the technology typically shows slow initial improvement, followed by accelerated improvement and then diminishing improvement. Performance of the technology in the early stages is said to be slow because of the fundamentals of the technology are not well understood. However, as firms gain more understanding about the technology, improvement in the performance of the technology accelerates. In addition, this attracts the global market towards the technology. As soon as this happens, the developer of the technology will try to focus on those activities that reap the greatest "improvement per unit of effort", which enables the performance to improve rapidly. Technology S-curves are also known as experience curves (Schilling and Esmundo, 2009).

A research study conducted by Sood and Tellis (2005) on fourteen different technologies found that technologies do not always show evidence of a single S-shaped curve. The evidence states that performance improvements of the technology occur over a long period with no improvements rather than a smooth S-shaped curve. Moreover, Foster (1986) characterised the period where two technologies are competing with each other as an unsettling, disordered or the period of discontinuity. These competing technologies will have their own S-curve. If the new technology performs higher than the old technology, then the relationship between the two S-curves will be regarded as being disconnected, but if it is lower than the performance of the old technology, then it is called connected. In any case, there can be multiple technology S-curve over some time. Some authors, like Foster (1986), Lu (2008) and Chang (2010), have tried to identify S-curves using different labels on the X and Y-axis (cited in Taylor and Taylor, 2012). These are shown in Table 1.

Table 1. Different labels on X and Y-axis of technology S-curve (Taylor and Taylor, 2012).

S. No	X-axis	Y-axis	Reference
1	Time	Diffusion and performance	Lu and Marjot (2008)
2	The amount of efforts (funds) put in developments.	Performance	Foster (1986)
3	Expenditure of engineering effort.	Performance	Chang and Baek (2010)
4	Investment in the development of a technology (e.g., hours worked, budget allocated, and researchers employed).	Performance	Nieto et al. (1998)
5	Time	Evolution of patent applications.	Andersen (1999)

6	Time	Cumulative sales generated by all products enabled by technology.	Debackere et al. (2002)
7	Time	Willingness of the customer to pay for the increased performance provided by the technology.	Adner et al. (2004)

Studies by Foster (1986), Sahal (1981) and Utterback (1994a) support the view that a consensus has developed regarding the shape of the technology evolution. Progress of technology follows a single S shaped curve. A further view is that the new technology performance starts below the performance of the old technology and ends above the performance curve of the old technology. Moreover, the existing literature also suggests that old technology and new technology will only cross each other's paths once in their TLC (Sood and Tellis, 2005). There are four stages in an S-curve (see Figure 7), the introduction stage, the growth stage, the maturity stage, and the decline stage.

2.3.2.1 Introduction stage

The introduction stage is the first stage in the technology S-curve where the technology will make slow progress in terms of performance. Two possible reasons for this could be: The technology may not be well known, and it may not attract the attention of the industry. New technology must overcome the bottlenecks before it can be translated into practical and meaningful product/service (Sood and Tellis, 2005).

2.3.2.2 Growth stage

Sood and Tellis (2005) explained that the second stage in the technology S-curve is the growth stage, which usually begins with new technology dominating the market. A continues research on the new technology facilitates to cross the thresholds and starts to snowball. At this stage, the preferences of the consumer and the characteristics of the product or technology coalesce. This stage, in turn, helps in improvement of the performance. Besides, standardization of this new technology in the industry attracts more and more researchers to study the new technology or the platform and results in rapid improvement in the performance. This rapid progress in performance leads to an increase in the sales of the products or services using that technology. An increase in sales helps in increase in the revenue and profit, which further supports investment in technology as well as improved performance.

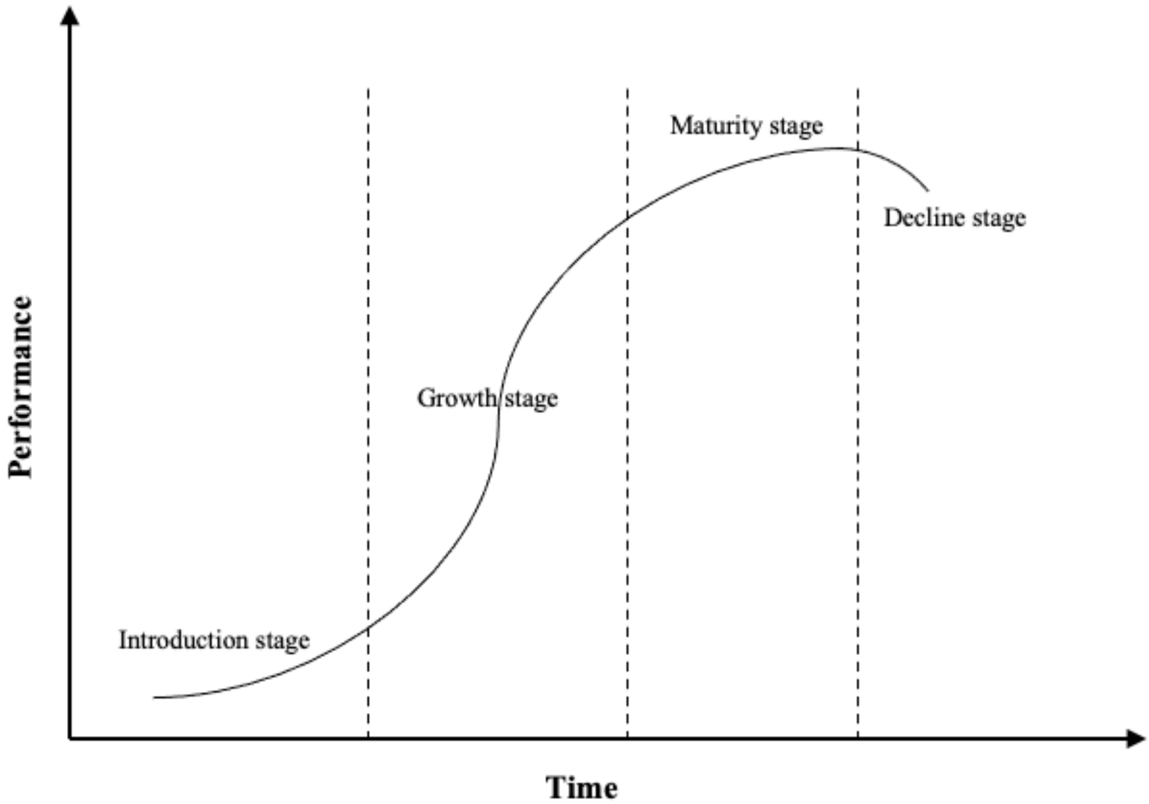

Figure 7. Technology S-curve (Sood and Tellis, 2005).

2.3.2.3 Maturity stage

After the growth stage, where the technology had a rapid improvement in performance, it reaches to maturity stage. From this stage, the progress of performance moves slowly or reaches its upper limit. Many authors proposed several reasons for this slow progress. Some of them mentioned that as the market ages, the focus shifts from 'product innovation to process innovation'. Others have mentioned that as the performance of technology reaches its ceiling point, firms secure fewer competitive advantages from the technology. One of the authors has mentioned that once the technology is in the maturity stage, it has reached its limits of scale (which means it is too complicated to work on further). Furthermore, to maintain the pace of progress, firms move to a new technology (Sood and Tellis, 2005).

2.3.2.4 Decline stage

The value of the technology declines as the new technology replaces it and slowly the old technology becomes obsolete and this is called the decline stage (Marjot and LU, 2008). From the study by Schumpeter (1939), researchers have described innovations using a wide variety of terms. They defined technology innovation based on its effects. However, researchers like Sood and Tellis (2005) defined technology innovation based on its attributes. Sood and Tellis (2005) defined the intrinsic characteristics of technology as a platform innovation, a component innovation, and a design innovation. Platform innovation is the rise of new technology, which is distinct in scientific principles from the existing technology. For example, the compact disk (CD) uses laser optics as a platform for reading and writing data, whereas the floppy disk used magnetism as a platform technology. When the innovation happens at the component level, but the technology platform remains the same, this is component innovation. For example, floppy disk and zip disks used different parts or materials for the component, but their technology platform was magnetism. Design innovation is the reconfiguration of connections and design of components within the same technology platform. For example, the size of the floppy disk was reduced from 14 inches to 2.5 inches over a while (Sood and Tellis, 2005). Even though it is a widely accepted model in the industry, the technology S-curve still has some limitations.

Exact limits of the technology are often considered differently by firms in industry. There is no firm conclusion that the shape of the technology performance is a simple S-shaped curve. Market uncertainty, component innovations or rival technology often lead to shortening the technology's life or extending it (Schilling and Esmundo, 2009). Empirical evidence from researchers further identified that new technologies may or may not start below the performance of the old technologies. Alternatively, new technologies may cross their competing technologies more than once (Sood and Tellis, 2005).

2.3.2.5 Alternative terminologies for technology S-curve stages

In order to have a complete review on the stages of technology, several other studies were also considered which are not consistent with the above views of technology S-curve. Those studies focused on linking stages of technology with managerial decisions (Taylor and Taylor, 2012). Based on the Utterback model (Abernathy and Utterback, 1978), a new four-stage model, called externally focused TLC, was developed. Its focus was on empowering managers with information on the phase in which their product fits. Based on this information, a manager determines the appropriate type of external partnership the organization can have for its growth. The external partnership could be an alliance, joint venture, merger, or an acquisition (Roberts and Liu, 2001).

Another perspective of the S-curve is the technology developer. The designed model for S-curve explains the evolution of technology from the idea development stage to product sales stage. The model comprises of six phases: technology development and its application, launch applications based on the technology, growth of technology application, the maturity of technology and degradation. For each phase, a different corporate (marketing) strategy can be applied by organizations to secure higher profits from technology (Ford and Ryan, 1981).

Recently, a new S-curve with a macro view was suggested. It considers not only the organizational perspective but also the entire economy during the transition between technologies. The new S-curve is similar to the product life cycle, and it includes the introduction, rapid growth, maturing and decline stages Kim (2003). In the study by Bevilacqua et al. (2007) on the S-curve, the stages were defined as conception, design and manufacture, service, and disposal. In another approach, Foden and Berends (2010) argued that the S-curve can consist of only activities that are associated with technology development. Based on this, a new framework was developed, which includes identification and monitoring, selection and approval, development research, acquisition and adaption, exploration, and review protection as stages. Table 2 summarizes the stages of the technology in S-curve from these different perspectives.

Table 2. Stages of the technology in S-curve from different perspective (Taylor and Taylor, 2012).

No.	Stages in the TLC	Source
Macro View:		
1	Discontinuity, ferment, dominant design, incremental evolution	Anderson and Tushman (1990)
2	Fluid, transient, specific	Abernathy and Utterback (1978)
3	Fluid, transitional, specific	Utterback (1994)
S-curve:		
4	Introduction, growth, maturity, decline	Haupt et al. (2007: 388)
5	Incubation, take-off, maturity	Cetindamar et al. (2010: 201)
6	Invention, innovation, diffusion, growth, and maturity	Cetindamar et al. (2010: 195)
7	Embryonic, growth, maturity, and ageing	Cetindamar et al. (2010: 195)
8	Fluid, transitional, mature and discontinuities	Roberts and Liu (2001)
9	Bleeding edge, leading edge, maturity, decay	Lu and Marjot (2008)
Alternative views:		
10	Fluid, transitional, mature and discontinuities	Roberts and Liu (2001)
11	Introduction, rapid growth, maturing and decline	Kim (2003)
12	Technology development, technology application, application launch, application growth, technology maturity and technology degradation	Ford and Ryan (1981)
13	Feasibility, justification requirements definition, engineering, system design, details design, test and pre-operation, implementation, operation, maintenance, and post-implementation audit/evaluation	Irani and Love (2000)
14	Conception, design and manufacture, service, and disposal	Bevilacqua et al. (2007)
15	Identification and monitoring, selection and approval, development research, acquisition and adaptation, exploitation and review, protection	Foden and Berends (2010)

According to Sood and Tellis (2005) researchers did not develop a single uniform theory on the S-curve, but the most emerging and compelling theory of TLC has been explained in the four stages of introduction, growth, maturity, and decline. On this basis and according to the existing literature, three premises are described. The first is that any successive technology's performance follows an S-curve path. The second is that the performance of a new technology starts from below the performance of the old technology. The third is that the performance of the new technology crosses the performance path of the old technology only once and ends above the performance of old the technology (Sood and Tellis, 2005).

Utterback (1994a) explained that at first the entrenched technology extends improved performance compared to a new challenger, which is still unperfected. Ander and Levinthal (2002) also supported the first premise that an established technology will dominate the new technology in the initial stage. Foster (1986), Constant (1980) and Utterback (1994a, p.160) stated that although the new technology performance path starts below the performance of a recognised technology, the new one will outperform the old one in a later stage of the life cycle. Two examples to support the argument cited by the authors were wind-powered ships replaced by steamships, and internal combustion engines were replaced by turbojet engines. For the third premise, Christensen (1997) and Foster (1986) postulated that a series of events will happen in the evolution of technology. New technology initially starts slowly in terms of performance and at some point, enters the growth stage and rapidly increases its performance compared to old technology. Moreover, at this stage performance of new technology crosses the path of old technology performance. The crossing of performance paths is deemed as the end of the effectiveness of the old technology (Sood and Tellis, 2005).

Based on the above three foundations, a study was conducted by Sood and Tellis (2005) on 14 different technologies to understand whether their performance path follows the S-curve or not. The results from this study revealed that technologies often have a slow start and a sudden growth in performance. The study also found that a single S-shaped path with a single inflexion point followed by a permanent plateau or maturity occurred in only four out of 14 technologies.

In the other nine technologies, the researchers did not find a single S-curve (Sood and Tellis, 2005).

For the following two premises, when a new technology reaches maturity, its performance is higher than that of the old technology. A pair of successive technologies' performance paths intersect once when the new technology surpasses the old technology in performance. However, as per the literature on the technology S-curve, most new technologies outperformed the old technology when they commenced. Conversely, a few new technologies did not perform better than old technologies even once, whereas some experienced brief periods of dominance over the old technology before they recouped their ascendance. The results showed three different types of crossings between any two consecutive technologies. In the first type of result, three out of ten technology pairs displayed no crossing. In those scenarios, either the performance of the new technology started higher than the old technology and continued to surpass the performance of the old technology or never crossed the performance of the old technology. The second type of result showed that three out of ten technologies showed multiple crossings. Moreover, in those three technologies, the new technology surpassed the performance of the old technology but could not be sustained in the long run. In total, only four technologies could show a single crossing of the performance curve from below the performance path of the old technology. In summary, the researchers could not find support for any of the three premises on the performance of competing technologies (Sood and Tellis, 2005).

2.4.3 Use of S-curve model in various industries

The S-curve model has been adapted across various industries. For example, to measure the utilisation of financial outlays of a construction project Konior and Szostak (2020), which used the S-curve representation to present the financial flows on a timeline using a cost chart. The S-curve demonstrates advancement of the investment project from the commencement of the construction works through to realisation. The variable incline of the cost curve reveals the changing progress of assignments per unit of time. Similar to the technology lifecycle, the S-curve for a construction project is flatter at the initial stage and moves steeper during the project's progression. Due to continuous research, the traditional S-curve model has been expanded in scope and frequently modified in the following ways: via the least square method, or S-curve regression model, or using the S-curve Bayesian model, which can be applied in the construction industry. However, Konior and Szostak (2020) suggested that the forecasted S-curve models proposed in various research studies, as a rule, are not precisely in line with the actual state of technology development.

Mohammed et al. (2021) conducted a case study on S-curve analysis to calculate the progress of planned project activities in the construction industry. In addition, the case study reviewed the contractor’s technique to overcome the project delays. In order to address the complications involved in controlling projects, the S-curves established on financials are applied to project management applications. For example, the costs vs. time S-curve was used for monitoring project progress. The scheduled and actual progress was compared to accelerate the remedial plans. The contractors and developers acknowledged that the S-curve was an effective medium for notifying progress. Consequently, the S-type distribution is considered appropriate in construction management and social economy domains.

The field of epidemiology explains the spread of contagious infections in a bounded environment through the S-curve model. For example, Omran (1971), cited in Netland and Ferdows (2016), has demonstrated analytically and empirically that infectious diseases transmit through the population in an S-curve pattern. First, the disease begins in a few susceptible people, then slowly circulates, then rapidly transmits and finally, when most of the population is infected, the rate of spread starts declining. Whereas Netland and Ferdows (2016) have indicated that implementing a lean practice observes an identical pattern. They are usually introduced in strategically chosen areas as a pilot test case because of less resistance to change and can exhibit rapid and perceptible progress. As more and more sites adopt the approach, improved results are delivered, persuading the other units in the plant to implement the technique. Conversely, when fewer units in the plant are left to implement the lean practice, the rate of adopting the practice slows down. Netland and Ferdows (2016) also described the relationship between two variables i.e., the change in performance of the plant as it executes more of a lean program using the S-curve model. The S-curve model has been employed for explaining various other phenomena, such as population growth, bacteria, crime, environmental change, and particle acceleration are a few other examples. Furthermore, apart from new technology development, the S-curve model has been used in management to explain innovation and the concept of maturing manufacturing strategy. Notably, in the disciplines mentioned above, the S-curve model is used to illustrate the spreading pattern of a phenomenon through time.

Finding the most appropriate instrument to provide the best estimate of used car prices can be demanding. Predictive modelling using statistical regressions or machine learning algorithms can be applied. Traditionally, linear regression is often used in pricing models. Moreover, linear regression is the oldest type of regression method explicitly used for the forecast (Salim and Abu, 202). However, due to the assumptions of linear regression, residual errors increased prominently as the data were scattered away from the central mean. Thus, its accuracy in defining a linear relationship in real-life situations can be inaccurate. By contrast, many research studies have found non-linear models to outperform linear models. For example, one of the non-linear models, the S-curve, has been considered suitable for describing many real-life phenomena. In addition, Aydin (2015) discovered that an S-curve model is the most suitable for predicting the performance of natural gas production compared to six other regression models: linear, logarithmic, power, exponential, inverse, and growth models (cited in Salim and Abu, 2020).

2.5 Technology Readiness Level

The Technology Readiness Level (TRL) framework was initially developed in 1974. Originally the framework had seven levels but in 1989 two more levels were added. Then for the first time in 1995, John Mankins systematised the TRL framework with nine levels in a white paper, which had a limited depiction of each level and its achievement criteria. For example, Mankin (1995, p. 32) defined the 9th level of TRL as "*small fixes/changes to address problems found following launch*". Later the foundations of the NASA TRL system led to defining technology readiness for the U.S. Department of Energy (DoE), the European Space Agency (ESA), the Department of Defense, the Department of Homeland Security (DHS) and others. In addition, NASA has used the TRL system for space and aeronautics applications (cited in Straub, 2015).

Mankins (2009) explained that the notions of the TRL framework were proposed in 1960, with its codification in a 1969 report expressing a need for a "*technology readiness review*". In 1970, a "*technology-independent scale*" was recognised, and by the late 1970s it was referred to as "*technology readiness levels*". The early TRL levels developed by Stan Sadin comprised seven levels with a brief characterisation of each of the levels. This version of TRL was published in 1989, and in the same year, Mankin added the eighth and ninth levels to the TRL scale in the context of the space exploration initiative. The TRL scale attained widespread use in the 1990s as part of an integrated technology plan for the civil space programme and in defence sector applications. The comprehensive set of definitions of the Technology Readiness Levels by Mankin in 1995 is still the basis of the TRL system today (Straub, 2015).

Brown and McCleskey (2000) proposed a new TRL level i.e., the tenth level, to suggest the difference between a single use in the operation and prolonged operational use. Later Sauser et al. (2006) proposed using a systems-level readiness metric, which helped address a lack of understanding of how various technologies were to be integrated and the categorisation of systems comprised of multiple technologies. This approach utilised a seven-level integration readiness level scale and a five-level system readiness level scale (cited in Straub, 2015). Philbin (2013) discussed the applicability of TRL in the context of university-industry research collaboration whereby universities tend to focus on low TRL levels whilst firms will be driven towards technology with a higher TRL.

The TRL framework has been utilised in various industries to measure technology development from the idea generation stage to the commercialisation stage. It can also be adapted to understand the capabilities and requirements of resources to develop technologies. The nine levels in the TRL scale can be classified into three stages. For example, TRL 1 to 3 level can be defined as lab scale. TRL 4 to 6 can be described as pilot scales, and TRL levels 7 to 9 can be called commercial scales (Rybicka et al., 2016). The following section explains each technology readiness level and TRL software descriptions are provided for illustrative purposes. Figure 8 shows the nine levels of the TRL framework (Straub, 2015).

2.5.1 TRL-1: Basic principles observed and reported

TRL-1 is the lowest level of technology maturation. Basic scientific research has resulted in the observation and reporting of fundamental principles at this level, thereby translating into more applied research and development (Mankins, 2007). In the software context, scientific knowledge is developed, underpinning the fundamental properties of software architecture and mathematical formulation (Straub, 2015). The cost to fulfil TRL-1 can range from low price to high price varying from discipline to discipline in which the scientific research is involved. In other words, the cost may be a tiny fraction of the entire allocated budget or cost equivalent or even more compared to the overall project. For example, the cost involved in exploring the aerodynamics or biochemistry domains would be significantly higher than studying computational algorithms involving one or more researchers (Mankins, 2007).

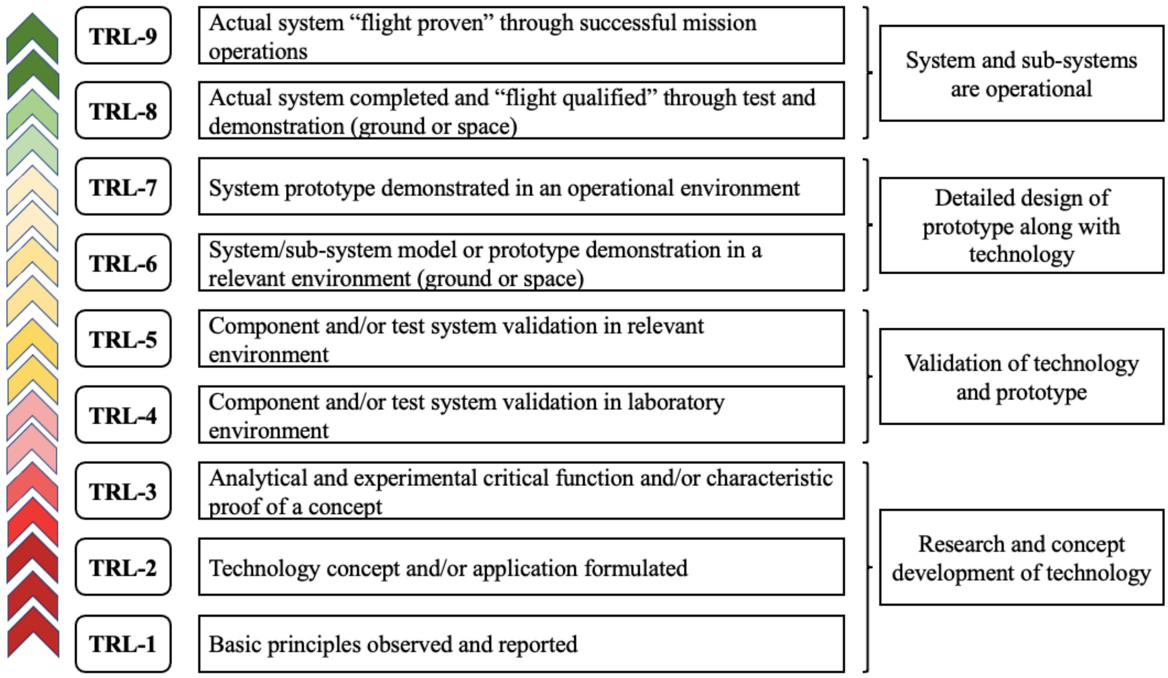

Figure 8. Technology Readiness Levels (Mankins, 2007; Straub, 2015).

2.5.2 TRL-2: Technology concept and/or application formulated

Invention commences at this level. Once the study of fundamental principles is observed, practical applications can be developed. However, the application is hypothetical, and no guarantee or precise analysis supports the conjecture. Basic properties of algorithms, models, and theories defined. Basic are principles coded and experiments are conducted with artificial data (Straub, 2015). The costs to complete TRL-2 are generally low. They are usually a tiny fraction of the expenses of an eventual system application involving the basic principles being studied. Most organisations may embark on these activities. However, it often occurs among universities, small businesses, and entrepreneurs (Mankins, 2007).

2.5.3 TRL-3: Analytical and experimental critical function and/or characteristic proof of concept

Active research and development (R&D) is commenced at this stage in the TRL framework. This stage comprises analytical studies to materialise the technology into an appropriate context and laboratory-based investigations to validate that the analytical forecasts are correct. In addition, these studies and experiments must comprise proof-of-concept validation of the applications/concepts developed at TRL-2 (Mankins, 2007). In the context of the software industry at this stage, non-integrated software components are used to validate the development of limited functionality (Straub, 2015).

2.5.4 TRL-4: Component and/or test system validation in the laboratory environment

Following successful proof-of-concept for critical functions or attributes, the fundamental technical elements applied to the design must be incorporated in order to achieve performance levels discussed at the concept level of a component. The validation at this stage must be devised to support the earlier vision and be compatible with the requirements of potential system applications. The estimated cost at TRL-4 is anticipated to be reasonable. Usually, the cost would be a modest fraction of the overall cost of an eventual system application (Mankins, 2007; Straub, 2015).

2.5.5 TRL-5: Component and/or test system validation in the relevant environment

At TRL-5, the adherence of the investigated component increases significantly because the fundamental technical elements must be combined with actual supporting elements to test the complete applications in a simulated or moderately naturalistic environment. One or more new technologies could be applied in the demonstration. For example, end-to-end software elements are executed in a suitable environment, a prototype enactment is developed by predicting the working circumstances performance. In this stage, R&D costs may be anticipated to be moderately high and be extensively technology specific. In addition, organisations can undertake R&D activities through formal sponsorship from government entities or venture capitalists. Critical functionality of software components is combined to validate the established interoperability and initiate architecture development. Applicable environments are defined, and performance in the environment is anticipated (Mankins, 2007; Straub, 2015).

2.5.6 TRL-6: System or subsystem model or prototype demonstration in a relevant environment (ground or space)

A significant step in the technology development process follows the completion of TRL-5. Then, at TRL-6, a prototype model or system would be tested in a suitable environment. Furthermore, the demonstration should be successful in fulfilling TRL-6 requirements. Not all technologies will experience a TRL-6 demonstration: the demonstration may portray an actual system application or be similar to the planned application but employing the same technologies. At this point, proceeding to the next stage is driven more by ensuring management confidence than by R&D provisions. For example, prototype implementations of the software and engineering feasibility are presented extensively (Straub, 2015). For TRL-6, R&D expenditures may be predicted to be high and mainly specific to the technology demonstration. However, these expenses would likely be similar but less than the investment(s) to reach TRL-7 in the same subject area. Therefore, an appropriate formal organisation could only embark on these activities, and because of the significantly increased costs, would almost always involve formal sponsorship through government or venture funding, whichever is suitable (Mankins, 2007; Straub, 2015).

2.5.7 TRL-7: System prototype demonstrated in an operational environment

TRL-7 is a significant development step beyond TRL-6, requiring an actual system prototype demonstration in the expected operational environment. For example, space is the operational environment in the case of NASA. In the case of TRL-7, the prototype should be almost or at the scale of the intended operational system, and the demonstration must transpire in the precise operational conditions. The goal of accomplishing this maturity level is to ensure the confidence of system engineering and management requirements more than technology R&D. Therefore, the demonstration must be a prototype of an actual planned application. However, not all technologies in all systems must be demonstrated at this level. This programmatic development step would typically be performed in cases where the technology and sub-system application is critical and high-risk to the mission (Straub, 2015). For example, a software goes live having all essential functionality for demonstration and test. In addition, most software bugs will be cleared. For TRL-7, R&D costs would typically be very high and could be a significant fraction of the ultimate system application total cost, depending on the scale and the preciseness of the system prototype demonstration being implemented. As a result, these expenses would be significantly greater than the investment(s) to reach TRL-6 (Mankins, 2007; Straub, 2015).

2.5.8 TRL-8: Actual system completed and "flight qualified" through test and demonstration (ground or space)

All technologies being used in existing systems go through TRL-8. In almost all circumstances, this stage is the end of actual system development for most technology elements. In the case of a space system devised by NASA, TRL-8 may contain the Design, Development, Test and Evaluation (DDT&E) through the theoretical first unit for a new type of launch vehicle. For example, the software will be entirely debugged and fully incorporated with all operating hardware and software systems. In addition, user, training, and maintenance documentation are completed. Finally, all functionality of the system/software is demonstrated successfully in simulated operational scenarios. TRL-8 may also implicate cases in which new technology is being incorporated into an existing system instead of developing a new system altogether. The costs in this stage are specific to the mission and operational requirements that a new system incurs, and they are typically very high. In most cases, these costs would be greater than the combined costs of previous TRL stages by at least five to ten times (Mankins, 2007; Straub, 2015).

2.5.9 TRL-9: Actual system "flight proven" through successful mission operations

All technologies that succeed in being applied in actual systems proceed to TRL-9. However, in almost all cases, the last bug-fixing elements of proper system development do not materialise until the first deployment of an existing system. For example, in a space system, there may be a need for minor fixes, such as a software change or modifications in operational procedures to address issues encountered following launch. Such transformations may include incorporating new technology into an existing system, such as a new artificial intelligence tool into an operational mission control centre like the one at the NASA Johnson Space Centre (JSC). The significant difference between TRL-8 and 9 is operations. Creating a new spacecraft is TRL-8. Whereas launching the spacecraft and employing it during an actual mission is TRL-9. However, this TRL does not usually contain pre-planned improvement of ongoing or reusable systems. These costs are specific to the mission; they would be high but significantly less than the cost of TRL-8 (Mankins, 2007; Straub, 2015).

2.5.10 Applications of TRL frameworks

Boretti's (2021, p. 1170) research study on the solar thermochemical splitting cycle field is an example to understand the usability of TRL. "*The thermochemical splitting cycle is applied to water or carbon dioxide molecules to produce hydrogen or carbon monoxide*". A thermochemical splitting cycle (TSC) has direct and indirect methods. Unfortunately, the TSC-direct method has a poor technology readiness level (TRL) despite being a good principle because it is still in the "*research to prove feasibility*" phase. It is in between TRL-2 and 3 stages. By contrast, over several decades, the TSC-indirect method benefited from the collaborative experiences with a nuclear heat supply. For these plants, the TRL is much higher.

Sadin (1989) emphasised that the TRL is a framework that communicates an understanding of technology maturity and risk. The levels are an expressive language to examine technology readiness across the organisation and domains. TRLs are instrumental in planning technology hand-offs between different groups across the organisation, for example, an R&D team and project management team. Furthermore, TRL is a systematic approach and ideal for technology-intensive system development because it acts as an essential handbook (cited in Olechowski et al., 2015).

Olechowski et al. (2015) highlighted those industries, such as defence, oil and gas, and aerospace, where safety is critical, are increasingly focusing on TRL as a tool for technology qualification. This growth transition will potentially continue, considering the allocation of grants and how incentivising TRL is employed as a scale as a basis for funding eligibility. European Commission's Horizon 2020 research and innovation programme is an example, and the study has recognised fifteen challenges encountered in TRL execution.

In other work, the study by Prasetio et al. (2020) explained increasing grant effectiveness in technology-based startups. Perusahaan Pemula Berbasis Teknologi (PPBT) is a technology-based startup programme for yearly seed funding introduced by the Ministry of Research, Technology and Higher Education of the Republic of Indonesia. This programme aims to increase tech-based businesses' growth and development to improve national economic advancement. The PBBT programme encourages commercialising local technology innovation developments and increasing the presence of technology-based startups in the country. This programme prioritises awarding grants to tech-based startups in eight fields: food, health and medicine, energy, transportation, information technology and communication, defence and security, raw material, and advanced material.

Since the PPBT grant is purposed mainly for a technology-based startup, one of the most important criteria is the technology readiness level. All startups applying for grants must report that their startup technology is between TRL 7 and 8. Karasakal and Aker (2017) explained that the PPBT programme's first criterion is TRL. It is not only used to assess the technical level but also the innervational aspect of the products. This criterion concentrates on "*state-of-the-art, competitiveness, ambiguity, and complexity of the technology in the products implementation and innovation level of the products or services*" developed by the technology-based startups.

2.6 Leadership skills

An individual or a team employed to evaluate, implement, and discover opportunities or ideas for creating value are called entrepreneurs (Reid et al., 2018). Conversely, an individual who facilitates action toward shared objectives and influences others to do the same is called a leader (Yukl and William, 2020). Currently, the literature states that an entrepreneur is characterised as a person who operates in highly volatile, unique, and uncertain circumstances. In order to address the complex nature of the new venture process, an entrepreneur needs to exhibit the necessary leadership skills (Leitch and Volery, 2017). At the same time, O'Connor et al. (2018a; 2018b) argued that organisations must establish entrepreneurial skills in their leaders. The above statements highlight a vital question i.e., are entrepreneurs essentially the leaders? Alternatively, are the leaders necessarily entrepreneurs? (Pollack et al., 2020).

It is believed that a person who has built and worked on their leadership skills will be or will evolve as a better entrepreneur. In addition, leadership enables building character and allowing someone to learn new traits they might not have previously possessed. Although a leadership skill set is not necessarily required to become an entrepreneur, it can play a vital role in creating a successful entrepreneur. Therefore, lacking leadership skills can negatively affect the entrepreneur's success (Kadwa and Barnard, 2019).

Felix et al. (2018) examined the influence of cultural leadership factors on entrepreneurship traits. The authors conducted a multiple regression analysis using data from the Global Entrepreneurship Monitor (GEM) of thirty-four countries. The results show that the leadership styles considered in the study had an impact on entrepreneurial activities. Similarly, this research study focuses on understanding the type of leadership styles the interviewees followed and their impact on entrepreneurial pivoting. Figure 9 illustrates six leadership styles that are defined in the following section.

Figure 9. Leadership styles (Saeed and Mughul, 2019; Banks et al., 2017; Wilson, 2020; Cailler, 2020; and Khajeh, 2018).

2.6.1 Transactional leadership

The transactional leadership style involves motivating followers by responding to their interests. In addition, this style emphasises the exchange between leaders and followers. The exchange consists of allocating rewards by the leader upon completing tasks and duties by followers. A transactional leader identifies what needs to be done and rewards the follower for fulfilling tasks. The simplest definition of transactional leadership is granting psychological or material rewards in exchange for work. The idea behind this leadership style is to promote the behaviours of desired followers by offering rewards and eliminating unwanted behaviours by issuing penalties (Alrowwad et al., 2020). The transactional leadership style encompasses three characteristics, namely a) contingent reward, b) exceptional management by playing an active role, and c) exceptional management by playing a passive role (Saeed and Mughal, 2019).

A contingent reward acts as a primary motivating factor, where the leader can specify expectations from the followers while explaining the benefits associated with the results. For example, a manager who guarantees a reward for demonstrating remarkable work can anticipate higher performance from team members (Raziq et al., 2018). Exceptional management by playing an active role includes quality management i.e., the leader will try to maintain the organisation's status quo. In exceptional management, by playing a passive role, the leader will only act following the emergence of issues (Purwanto et al., 2020). A study was conducted by Zeach and Baldegger (2017) to understand different leadership behaviours in startups. In that study, they found that the transactional leadership style negatively affects smaller firms and positively affects larger firms. By contrast, Jia et al. (2018) have argued that transactional leadership significantly contributes to innovation.

2.6.2 Transformational leadership

Bass (1985) integrated transforming and transactional leadership concepts for studying formal organizations and understanding the psychological phenomenon of transformational and transactional leadership. This author was also credited for defining the term transformational leadership. However, his work was based on Burns' (1978) concepts of transforming and transactional leadership. The transformational leadership style is defined as leaders who encourage and motivate their followers to achieve outstanding results. At the same time, transformational leaders develop leadership skills in their followers (Brown et al., 2019).

A study by Avolio et al. (1999), as cited by Brown et al. (2019, p. 12), indicated that transformational leadership includes four primary dimensions: "*idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration*". Idealized influence explains that the leader acts as a role model to followers for high ethical behaviours. Inspirational motivation explains the leader's capacity to communicate an inspiring vision to the followers. The third dimension is intellectual stimulation, which refers to developing and supporting the followers' creativity, and the fourth dimension relates to individualized consideration i.e., attending to individual requirements and problems of followers (Kwan, 2020).

The transformational leadership style is associated with the leader's moral and ethical inclination. Therefore, transformational leaders are more inclined toward what is morally right and focus on protecting individuals' dignity and rights. Although both transactional and transformational leadership styles share this attribute, transformational leaders are more prone to utility maximization. Transformational leaders display a higher sense of integrity, significant moral development, and improved ethical behaviour. In addition, this leadership style is inclined towards "*diversity, inclusivity, and social responsibility*" in an organisation. Leadership styles are linked to strategic decision-making skills and stress various types of justice. For example, the transformational leadership style emphasises social justice. Transformational leaders support safeguarding followers' interests and assuring the appropriate treatment of all individuals in their efforts (Brown et al., 2019).

Transformational leaders transform followers' fundamental values, thoughts, and perspectives to perform beyond the minimum levels specified by the organisations. The significance of the transformational leadership style is the process i.e., the leader develops followers' commitment to the objectives of an organisation and enables them to achieve organisational goals. In other words, a transformational leader influences followers' development and transformation (Siangchokyoo et al., 2020).

2.6.3 Charismatic leadership

Charismatic leadership is defined as "*values-based, symbolic, and emotion-laden leader signaling*". Charismatic leadership is associated with the leader's effectiveness, followers' job performance and perspectives, and the firm's performance (Ernst et al., 2021). House (1977) introduced the concept of charismatic leadership. Antonakis et al. (2016) mentioned three dimensions: "*a) Justifying the mission by appealing to values that distinguish right from wrong (attributions), b) Communicating in symbolic ways to make the message clear and vivid, and also symbolising and embodying the moral unity of the collective per se (behaviour) and c) Demonstrating conviction and passion for the mission via emotional displays (articulating a vision)*" (cited in Banks et al., 2017). However, Banks et al. (2017) mentioned that these dimensions are similar to existing dimensions of transformational leadership. For example, attributions and behaviours are similar to idealised influence and articulating a vision is the same as inspirational motivation.

Karim et al. (2020) define charismatic leadership as the capability to exhibit a form of authority, which is understood through the perception of an outstanding individual. In addition, leadership scholars have debated extensively that charismatic leaders use impression management approaches to improve their followers' obedience to them. Charismatic leaders who have a robust ethical orientation create more suitable workplace surroundings. In addition, charismatic leaders communicate in such a way that followers are inspired to carry out their leader's vision.

Sociologist Max Weber used the term 'charismatic' to define a form of influence not established on tradition or authority, whereas on the perception of individuals that their leader is gifted with exceptional capabilities (cited in Karim et al., 2020). Moreover, charismatic leadership has attracted the attention of researchers because of its positive connection with organisational performance. Karim et al. (2019) pointed out three conceptual issues: a) charismatic leaders are unusual or exceptional, b) charisma as a quality or an individual characteristic is part of the charismatic leadership process, and c) charismatic leadership's dark side.

Finally, charismatic leaders have the characteristics of individuals with superior levels of dominant tendencies, pride and the correctness of their opinions. Weber's charismatic leadership model was founded on two fundamental principles. The first principle is that followers should have goals, purpose or aspirations. The second principle is that followers' submission to their leader is based on the leader's charisma, which leads to the realisation of their goals or aspirations (cited in Karim et al., 2020). Zhang et al. (2020) argued that recent empirical findings from studies by DeCelles and Pfarrer (2004) and Antonakis et al. (2016) indicate that the charismatic leadership style may in some cases lead to unethical behaviour, which creates uncertainty in organisations. Although charismatic leadership can positively impact followers' behaviour in societies, it may also lead to unfavourable consequences.

2.6.4 Democratic leadership

Democratic leadership is also known as the participative leadership style and concentrates on employing followers as equals. It downplays corporate hierarchy and highlights the significance of allowing employees to express their ideas and contribute to organisational performance. A democratic leader needs to distribute leadership opportunities throughout the institution. Democratic leadership emphasises four things: involvement, empowerment, communication, and engagement as its core goals (Wilson, 2020). Hanaway (2019) suggests that communication is the one talent that is essential to successful leadership. Furthermore, communication must remain constant, evident and two-way between leader and follower (cited in Wilson, 2020).

The democratic leadership style is an ability of a person to influence others to collaborate and accomplish goals. The democratic leader and followers must mutually agree to carry out all the activities. The advantage of the democratic leadership style is that the leader can regulate every duty and authority of the organisation's management, providing each manager with a clear division of responsibilities. This style will lead to the maximisation of results as one does not interfere with another one's work (Syamsidar et al., 2021).

A democratic leader will determine the action plan, conduct the activities openly and transparently, and keep parties involved in the process in the loop. This leadership style is a characteristic of open leadership, so a leader must deliberate in making decisions. Democratic leadership creates an exciting, friendly work environment and improved management of followers' work to realise goals more optimally. In addition, when a democratic leadership style is adopted, it gives a sense of ease in carrying out the task. Individuals require this comfort because it helps them carry out the job with confidence and enables a person to do a job optimally (Syamsidar et al., 2021).

There is potential for highly inefficient execution and flawed decision-making in the democratic leadership style. However, democratic leadership is also known for motivating employees by appreciating their thoughts and ideas to accomplish tasks. Another primary concern associated with this leadership style is that the persons involved assume an equal stake in the decision-making with a shared level of expertise. The study by Elenkov (2002) indicated that democratic leadership positively impacts organisational performance as it provides opportunities for employees to communicate and execute their innovative ideas as well as experience the decision-making process (cited in Khajeh, 2018).

This leadership style also trains future leaders and helps the organisation in the long run. Moreover, in a democratic leadership style, compliments and criticism are given objectively.

A democratic leader focuses on group discussions and group participation. As a result, it gives a sense of responsibility and positively influences the employees to perform optimally (Khajeh, 2018).

2.6.5 Autocratic leadership

The concepts of autocratic and democratic leadership were popularised when Lewin et al. 1939 (cited in Caillier, 2020) published the outcomes of experiments involving youngsters and adult leaders. Autocratic leadership, also known as authoritarian leadership, refers to leaders' practices to centralise authority, control, and decision-making. In other words, autocratic leaders employ control tactics in companies—leaders who follow the autocratic approach view associates as either contributors or obstructions to efforts to fulfil their goals. Autocratic leadership is usually correlated with overbearing or abusive leadership styles (Harms et al., 2018). Therefore, practices such as autocratic leadership are often perceived negatively. As a result, employees may rate the performance of such leaders as low, irrespective of their organisation's performance (Caillier, 2020).

Furthermore, autocratic leaders do not encourage a participatory management atmosphere. Instead, they adopt a dictatorial manner, thinking that somebody with a similar background is superior and should enjoy certain privileges. Consequently, they do not tolerate conflict of ideas (Harms et al., 2018). Moreover, due to the dominating nature, autocratic leadership can limit individuals' contributions to the organisation. However, autocratic leadership can be helpful in certain circumstances, such as when undesirable decisions need to be taken (Caillier, 2020).

Autocratic leaders are often bossy and want their followers to work according to them. Autocratic leaders typically retain decision-making rights to themselves. Studies conducted by Iqbal et al. (2015), Bhargavi and Yaseen (2016), and Igbaekemen and Odivwri (2015) revealed that autocratic leaders are less innovative and encourage one-sided exchange, thereby resulting in severe effects on the motivation and satisfaction level of the employees. In addition, communication and workplace socialisation is not encouraged in autocratic leadership. As a result, it leads to organisational disputes and affects overall performance negatively. However, the autocratic leadership style can be effective in the short term. This leadership style is more suitable for projects that must be completed within a stipulated timeline. An autocratic leader is the one who determines the actions, procedures and guidelines of the organisation and anticipates the employees to follow the same. In addition, these leaders do not have much trust in their followers (cited in Khajeh, 2018). A study of business employees (N=215) in the UK by Rast et al. (2013) identified that employees who are dealing with self-uncertainty show more support to their organisational leader if they consider their leader as a non-autocratic than autocratic (cited in Hogg, 2021).

2.6.6 Bureaucratic leadership

In 1947, Max Weber presented the bureaucratic leadership theory in order to explain the efficient functioning of large-scale organisations based upon predetermined rules and regulations with a clear division of responsibility and a hierarchy of authority (cited in Nag and Farhat, 2021). Conversely, the theory’s functioning can be illustrated as a straight line with no room for deviations and no flexibility. The followers under this leadership style are expected to adhere to their superiors’ instructions strictly. The bureaucratic leadership style is mainly accepted and practised in government sectors, especially when handling a large and disciplined organisation, such as the state administration. The rigid framework in central and state governments comprising the ministries and departments is apparent from their norms of functioning (Nag and Farhat, 2021).

Bureaucratic leaders influence the individuals under them to pursue their policies and procedures. These leaders are highly determined because of their processes and procedures rather than their influence on followers. As a result, bureaucratic leaders are considered to be unfriendly. This leadership style is not very effective in the development and motivation of the employees. The primary focus of these leaders is tasks being completed systematically. Ojukuku et al. (2012) explained that bureaucratic leadership hurts organisational performance (cited in Khajeh, 2018). This leadership style is effective for small projects when the jobs are to be completed by following a specific procedure (Khajeh, 2018).

Khan et al. (2015) explained that bureaucratic leaders are the ones who follow "*by the book*" Every task must be performed according to a procedure or policy. In case of deviation from the specified process, the leader seeks permission from the superiors. An individual who follows a bureaucratic leadership style is more of a manager than a leader. This leadership style can be helpful under certain circumstances, such as when employees must perform routine jobs frequently. For example, cash handling in banks or operating heavy machinery, which requires following a definite set of procedures. However, the bureaucratic leadership style has a negative impact on employees as they lose interest in their jobs.

2.7 Conclusion

The study identified and explained the literature on the following theories and frameworks: entrepreneurship, technology entrepreneurship, Leans Startup Approach, technology S-curve, technology readiness levels and leadership style. This chapter discusses the studies of various researchers in entrepreneurship and technology entrepreneurship along with the framework developed by Speigel and Marxt (2011). Similarly, the study illustrated the work of Ries (2011) and explained the Lean Startup Approach.

This study is focused on understanding the theory of pivoting and the factors that initiate those pivots. Therefore, the study has conducted a comprehensive literature review to identify different types of pivots and the factors that trigger those pivots. The study has identified fourteen pivots categorised into product-level, market-level, strategy-level, and team-level pivots from the studies of Ries (2011), Bajwa et al. (2017) and Hirvikoski (2014). Similarly, eleven factors were identified from the studies of Bajwa et al. (2017), which are categorised into external and internal factors.

In order to understand the life-cycle stages of technology (and level of maturity), the study has evaluated the technology S-curve and technology readiness levels (TRL) frameworks. The technology S-curve helps to understand the life-cycle stage of technology in four stages: introduction, growth, maturity, and decline. Whereas the technology readiness levels have nine levels to describe technology development before it is commercialised. Both S-curve and TRL help the research study comprehend technology's role when tech startups pursue pivots. Additionally, the study examined six different leadership styles to investigate the findings of Grimes (2018) and Crilly (2018) on entrepreneurs being rigid towards pivots due to psychological ownership. In the next chapter, the study will present the conceptual framework and describe the research questions designed based on the literature review.

Chapter 3: Conceptual framework and research questions

3.1 Introduction

Reading a doctoral thesis encourages one to view its relationship to other research and it can lead to the question of why the research was devised a certain way. Furthermore, to justify the relationship among theories or research studies, a researcher designs a conceptual framework to highlight how the research contributes to the knowledge base.

3.2 Conceptual Framework

Miles and Huberman (1984) defined the conceptual framework as the map of a research study, and they implied that conceptual frameworks evolve as the research study progresses. According to the authors, a conceptual framework identifies the boundaries of the research and helps in planning, analysing, and concluding the research study. Whereas Weaver-Hart (1988) described a conceptual framework as a framework that includes an intrinsic dilemma because concepts are notional, whereas frameworks are substantial. Therefore, the term 'conceptual framework' itself is conflicting. However, Weaver-Hart acknowledged that a conceptual framework is a tool for a researcher to organise and support the ideas while systematically placing conceptions in the context of the study. Hence a conceptual framework is a theoretical summary of the engaged study and order of research activities in the research study (cited in Leshem and Trafford, 2007).

Leshem and Traford (2007) analysed the opinions of different researchers on conceptual frameworks. For example, Berger and Patchener (1988) suggest that a literature review illustrates a research study's conceptual or theoretical framework. They constitute two questions: a) Has the conceptual framework been clearly defined and explained how it is connected to the research problem; b) Is there a clear connection between the theory, previous findings, and purpose of the present study? These two questions enable us to understand whether the conceptual framework guides the research process. Rudestam and Newton (1922) explained the conceptual framework as a graphical description of independent and dependent variables in a research study. They also explained that research questions and implications for further study are linked to a conceptual framework (cited in Leshem and Traford, 2007).

According to Kivunja (2018), the conceptual framework is the logical conceptualisation of an entire research project, meaning it is a metacognitive, thoughtful, and functional element of the entire research process. Therefore, the conceptual framework contains the researcher's ideas of the research subject, literature review, methodology, data analysis and interpretation of results. In turn, this means that a conceptual framework should address the following questions about the research study:

1. What is the significance of the research study?
2. What are the aims and objectives of the research study?
3. How does the researcher plan to conduct the study?
4. How will the researcher interpret the data?
5. Which paradigm will be applied?
6. How will the results be reported?

In order to improve our understanding of the entrepreneurial journey in regard to pivoting and the impact of technology, it is useful to synthesize a conceptual framework that builds on the relevant sources in the literature. A conceptual framework helps in laying the foundation for a research problem and guides the research process through the process of designing, conceptualizing, and organizing the different stages of the research process (Rocco and Plakhotnik, 2009). There are three types of conceptual framework, namely taxonomy, visual representation, and mathematical description (Emans, 1970). The study has adopted the visual representation, which presents a picture to explain the research study.

The research study aims to validate different types of pivots and the factors that initiate a startup to pivot as well as identify new pivots and factors not described in the literature. At the same time, the study's objectives are to understand whether the phases of technology entrepreneurship influence pivoting and whether the stage of technology in the technology S-curve impacts pivoting. Since the study examines the impact of technology maturity on pivoting, the technology readiness level framework is also considered to understand whether TRL levels influence pivoting.

The literature review identified that entrepreneurs displayed psychological ownership towards pivoting concerning their initial business idea. Therefore, the study also investigates whether tech entrepreneurs following any specific leadership style are more inclined to feel psychological ownership of their business ideas. Similarly, the study has discussed the domino effect due to pivoting as well as creating and sustaining value proposition(s) due to pivoting in the previous chapter, which will be investigated. Figure 10 presents the conceptual framework. The framework helps in designing research questions for the research study. Each research question is designed to improve the current understanding of entrepreneurial pivoting with respect to one of the abovementioned theories/frameworks at a given time.

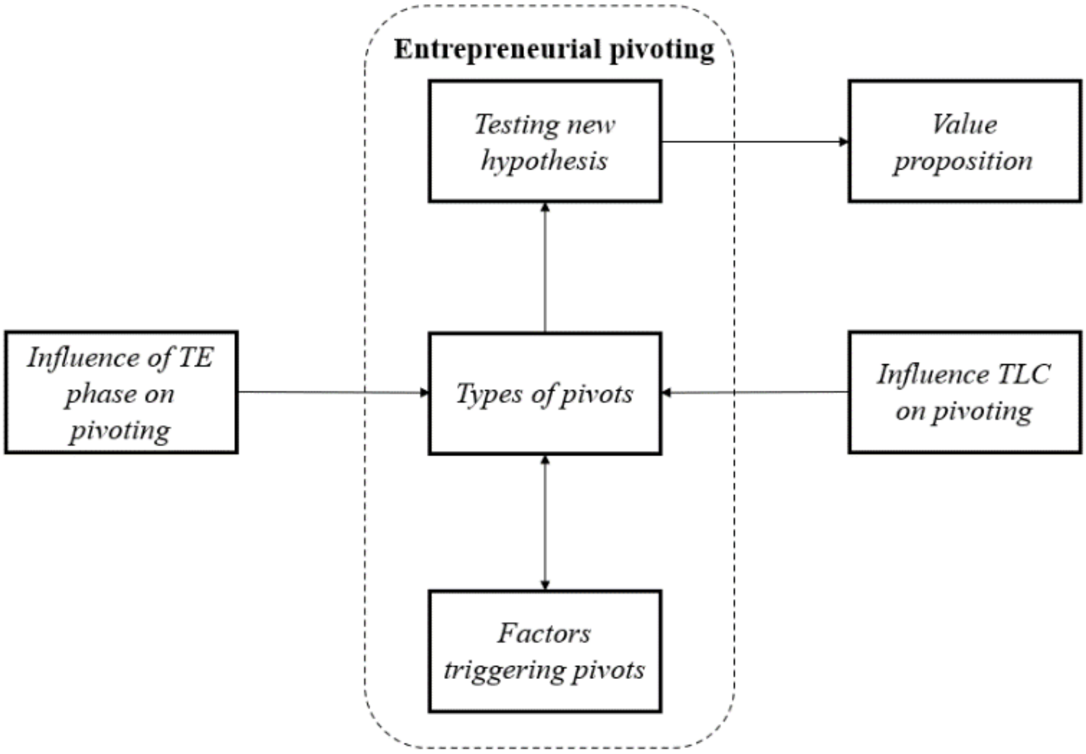

Figure 10. Conceptual framework of the research study.

2.3 Research Questions

Qualitative research begins with a question. Therefore, asking the right research questions is crucial for guiding the research study in the correct direction. Framing good questions does not necessarily lead to sound research, but inadequately constructed research questions will likely impact the study in a negative way. Research questions are the tool a researcher uses to understand the intentions and views of people involved in social interactions. Therefore, continuous questioning is an integral part of qualitative research studies to understand the perspectives of individuals. Scholars like Creswell (2007) commented that changing questions during the research process signifies increased understanding of the situation. Good practice in qualitative studies is that questions are reviewed at all stages of research. For example, Flick (2006) pointed out that reflecting on research questions is vital for evaluating the appropriateness of the researcher's decisions at several points (cited in Agee, 2009; Williams, 2007).

One crucial factor in writing the initial research questions is the focus of the study. As mentioned above, a question can be considered a tool to understand the phenomena under investigation. The research questions are not about simply asking what happened. Instead, the purpose is to understand the complexity of the matter. Focusing on questions is an iterative and reflective strategy that leads to specific data and information resulting in adding new knowledge to a more extensive field of study. The role of research questions is to describe the purpose of a research study. While drafting research questions, it is essential to frame the words so that the phrasing implicitly or explicitly connects with underpinning theory. Another important point when phrasing research questions is ensuring that they are answerable within a realistic timeframe.

Three questions to ask oneself while preparing research questions are as follows:

1. What should be asked?
2. How is it being asked?
3. What data will a researcher need to provide a good answer?

The research questions for this study are explained in detail and they are as follows:

RQ-1. How can a tech startup change its direction through pivoting?

RQ-2. What are the factors that cause a tech startup to change direction and pivot?

The first two research questions validate existing types of pivots and factors and identify new ones—Figure 11 illustrates the different pivots and factors identified in the literature review that can lead a tech startup to change its direction and pivot. The study is also concerned to find out whether there is a correlation between the pivots and factors.

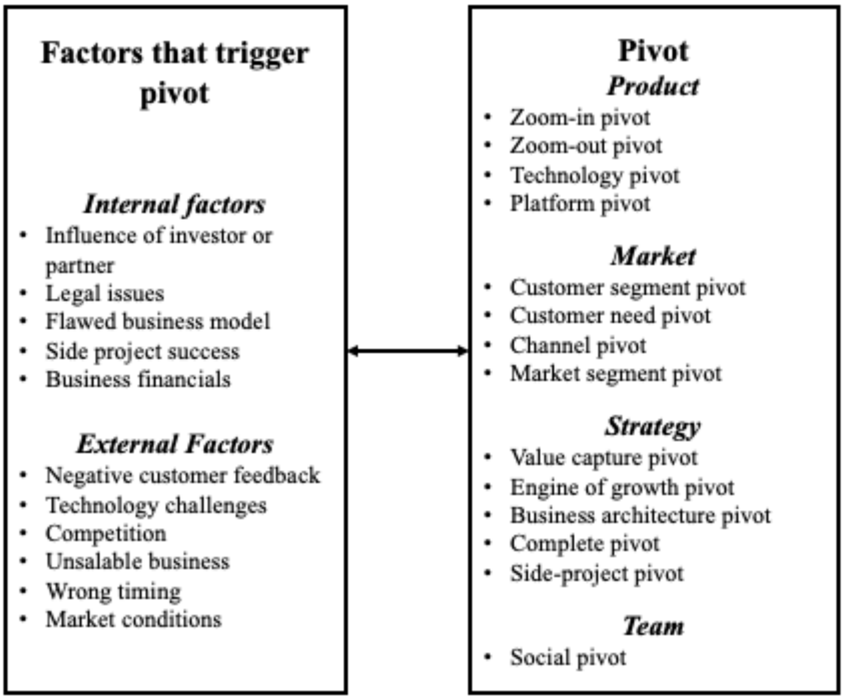

Figure 11. Pivots and factors listed in LSA literature (Ries, 2011 and Bajwa et al., 2017).

RQ-3. Does the phase of technology entrepreneurship influence pivoting?

This research question considers two theories i.e., technology entrepreneurship and the Lean Startup Approach, and the objective is to ascertain whether a correlation exists between the phases of TE and pivoting by tech start-up. For example, whether any phase of TE influences pivoting or not. If yes, can the study classify different types of pivots based on the phases of TE? Figure 12 illustrates three phases of TE, along with different types of pivots, while linking them to each phase.

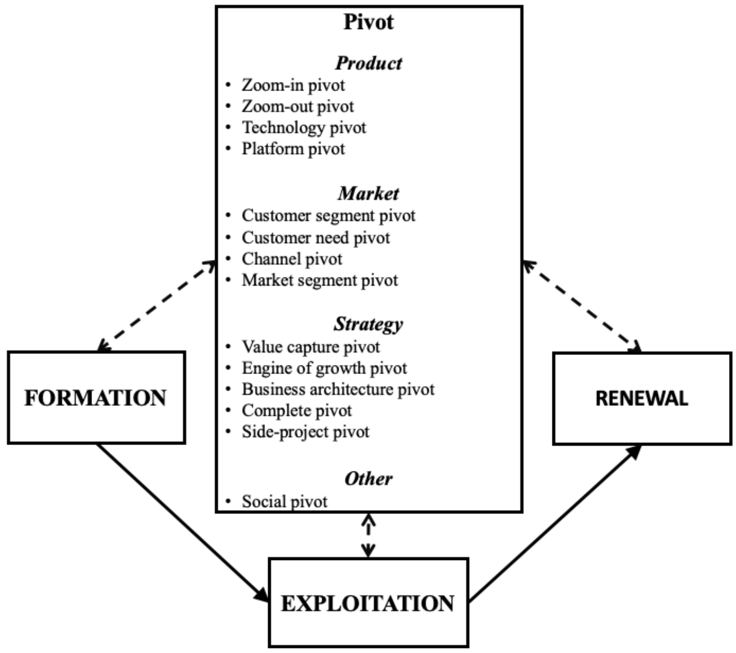

Figure 12. Three phases of TE and different types of pivots (Ries, 2011; Spiegel and Martxt, 2011).

RQ-4: Does the corresponding stage of the technology in the technology S-curve influence pivoting by tech startups?

The fourth research question focuses on studying two different theories i.e., the technology S-curve and the Lean Startup Approach. Studying these two theories will help to understand whether technology maturity influences pivoting. Figure 13 shows all four stages of technology in the technology S-curve, and different types of pivots. One of this study's objectives is to understand whether stages of technology in the technology S-curve impact pivot.

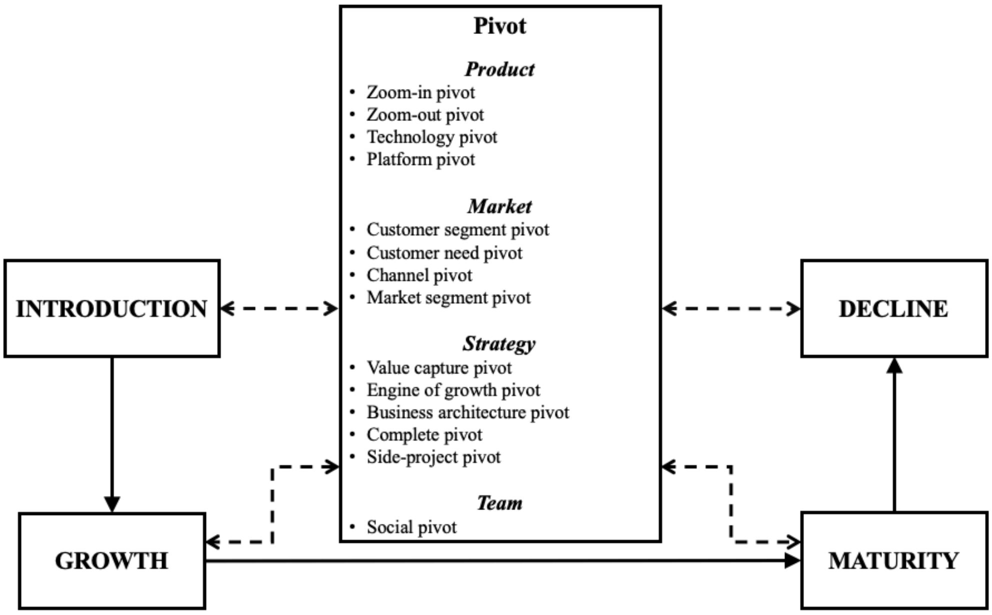

Figure 13. Stages of technology in the technology S-curve and different types of pivots (Ries, 2011; Sood and Tellis, 2005).

RQ-5: Does the TRL of the startup's primary technology influence pivoting by the startup?

The fifth research question discusses the impact of technology maturity on pivots by studying technology S-curve and pivoting from the Lean Startup Approach. The technology S-curve discusses the life cycle of commercialised technologies that are recently entered into the markets. However, it does not examine the technologies that are still in the developing stage. Many tech startups use developing technologies that are yet to become industry standards to gain a competitive advantage. Therefore, the study has selected the technology readiness level theory that explains the stages of technology development. The fifth research question investigates TRL and pivoting theories in order to understand whether technologies in developing stages influence pivoting using TRL—figure 14 explains nine levels in TRL and different types of pivots linked to each level.

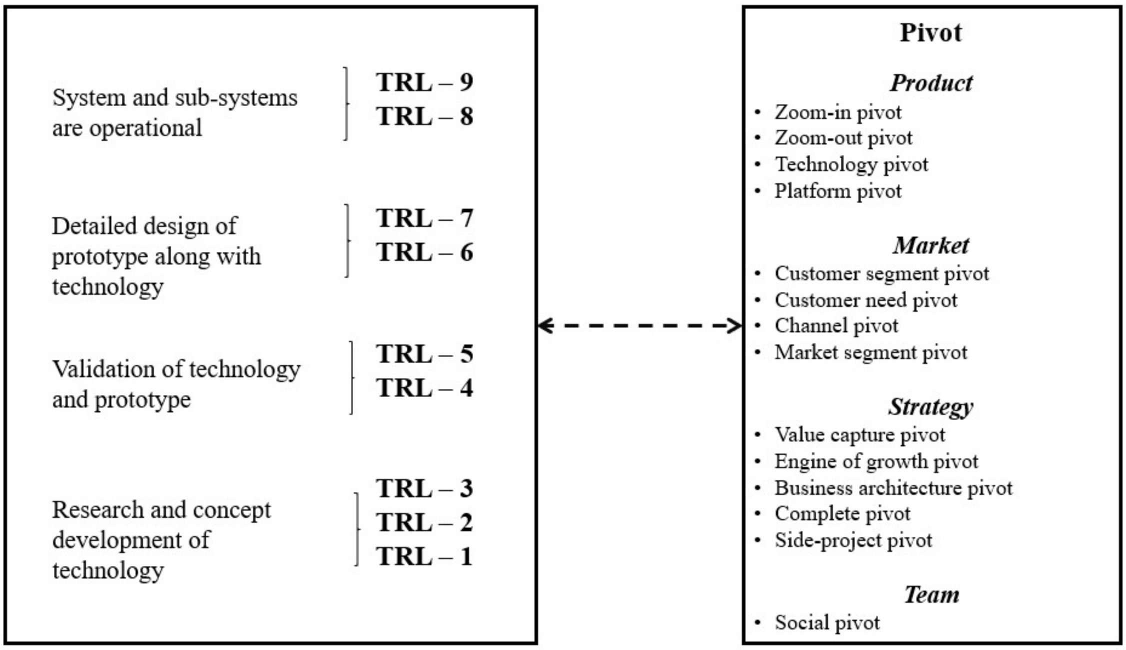

Figure 14. Nine levels of TRL and different types of pivots.

RQ-6: Does a tech entrepreneur face psychological ownership issues while pivoting?

Research studies from Felix et al. (2018), Grimes (2018) and Crilly (2018) emphasised that entrepreneurs display psychological ownership towards their initial business ideas. Therefore, they may oppose the idea of pivoting, which could cause a loss of an opportunity, hinder the growth of the startup or lead to its shutdown. Therefore, the research study investigated different leadership styles explained in the literature review chapter to understand whether tech entrepreneurs encounter psychological ownership with respect to their initial business idea. In addition, whether any particular leadership style followed by a tech entrepreneur leads to more psychological ownership issues than others. Figure 15 represents leadership styles that could potentially generate psychological ownership issues for tech entrepreneurs.

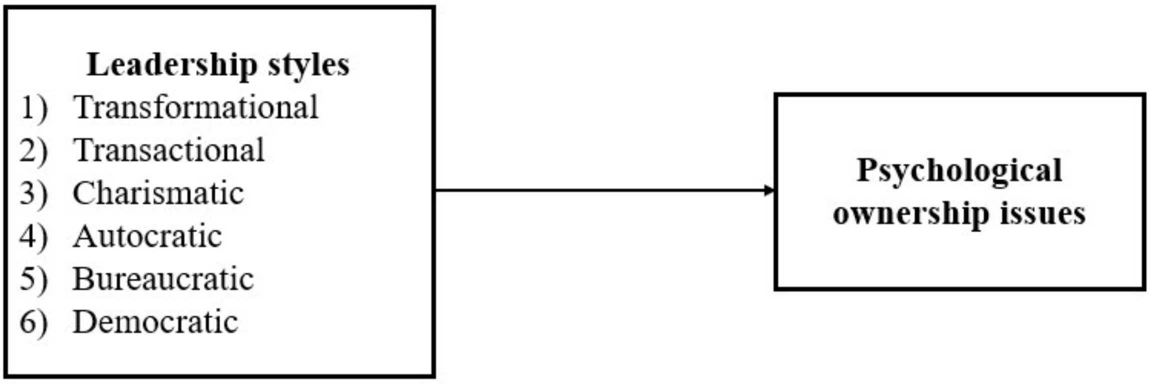

Figure 15. Leadership styles that could potentially generate psychological ownership issues.

RQ-7: Can a tech startup create and sustain its value proposition through pivoting?

The studies by Guo et al. (2021), Kirchberger et al. (2020) and Wouters et al. (2018) explained a value proposition as the uniqueness of a product or service delivered by a startup to its customers by addressing their necessities. Therefore, the study investigated whether pivoting could create and sustain a value proposition. Figure 16 illustrates different types of pivots and the value proposition created and sustained by the startup.

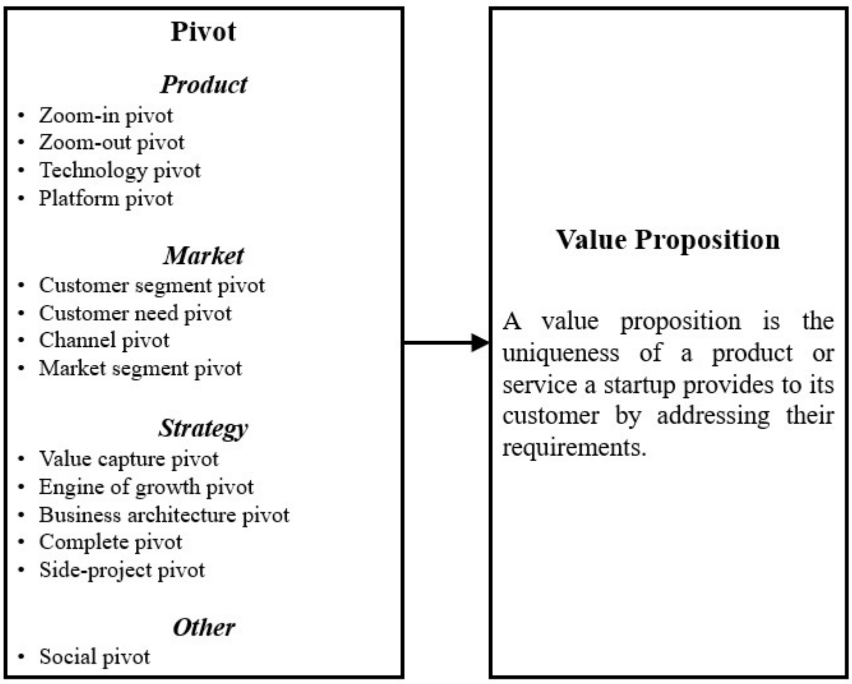

Figure 16. Value proposition due to pivot(s).

1.3 Conclusion

The research study aims to understand how pivoting has affected practising high-tech entrepreneur's journey and identify the factors that trigger pivoting. The study also aims to investigate the role of technology in pivoting through understanding how technology impacts the entrepreneurial journey. The research study was conducted in the United Kingdom (UK). The UK is currently a hub for high-tech firms due to several reasons. Cities like London and Cambridge have clusters of universities, which provide access to highly skilled labour for tech startups and access to startup capital in these regions. London is considered a hub for locally established startups and larger tech firms from the United States and other parts of the world because of access to capital markets, a rich pool of knowledge workers, a shared language, and entry to the European market. This research focuses on the UK rather than other countries worldwide as there may be different factors present in other countries that affect the initiation and survival of startups. Moreover, reviewing tech startups in more than one country requires analysing additional variables, which would require an extension to the timeframe for the research project.

In order to support an improved research outcome, an extensive literature review and a robust research methodology are essential. Therefore, the project uses a qualitative research methodology to derive empirical solutions for theoretical concepts on entrepreneurial pivoting. Furthermore, through qualitative techniques, it is possible to explore and understand the experience of tech entrepreneurs and the impact of technology in the pivoting process. The next chapter discusses how the research study has applied the qualitative approach to collect and analyse the data.

Chapter: 4 Research Methodology

4.1 Introduction

The purpose of a research study is primarily to identify a solution or discover new knowledge. In addition, a study helps to improve the understanding of a specific subject. However, the credibility of a research study relies on the procedure the researcher follows (Huges and Sharrock, 2016). Therefore, understanding the research approach is essential. The research approach has three critical components: research philosophy, design, and methodology (Creswell, 2014). Furthermore, a research study consists of different philosophical assumptions and procedures. Therefore, researchers must appropriately identify their research approaches (Huges and Sharrock, 2016). There are significant differences in research philosophy, assumptions, strategies, and methods for quantitative and qualitative research approaches (Creswell, 2014).

This chapter presents the methodology that has been adopted for conducting the research study and data collection process. The following sections explain the research philosophy, research design, qualitative research methodology, and how the study has collected primary and secondary data.

4.2 Research Philosophy

Research philosophy directs researchers in selecting the most suitable approach and technique in research. Research philosophy is categorised into ontological (i.e., assumptions about realities that a researcher encounters during research), epistemological (i.e., assumptions about human knowledge), and axiological (i.e., to what extent a researcher's values influence the research process) (Saunders et al., 2019).

Traditionally, ontology is regarded as a component of metaphysics that seeks to explain "*the structure of reality or the study of being*" (Hathcoat et al., 2019, p. 102)—here the authors explained that historical and philosophical argument concerning ontology centred on the notion of realism. In social sciences, a realist ontology generally means that a research phenomenon exists as an entity irrespective of the researcher's contribution to the study.

Similarly, Hathcoat et al. (2019, p. 103) described epistemology as a part of philosophy that examines the qualities, limitations, and rationale behind knowledge. Epistemology focuses on understanding "*What is knowledge? What is the relationship between the knower and the known? How are knowledge claims justified?*". Epistemology is a relatively broad area, Hathcoat et al. (2019) highlighted a framework provided by Crotty (1998), which summarises three epistemic positions: a) objectivism, b) constructionism, and c) subjectivism.

Two significant differences between quantitative and qualitative methodologies are the formation of concepts. One difference concerns ontology. A qualitative researcher applies a semantic approach and works to define the attributes of a concept that are inherently necessary. In comparison, a quantitative researcher assumes an unmeasured variable and then seeks to determine appropriate indicators that have a relationship with that variable (Goertz and Mahoney, 2012). The second difference concerns epistemology. In the qualitative method, the challenges of knowledge generation are tied to 'fuzziness'. By contrast, in quantitative methods, the challenges of knowledge generation are tied to 'error'.

According to Creswell (2014) and Mertens (2009), there are four main management philosophies or research paradigms, i.e., a) positivism, b) constructivism, c) transformativism and d) pragmatism. Research studies have adopted various descriptions and classifications of research paradigms and philosophies. For example, Guba and Lincoln (1994) specified four paradigms for the qualitative approach: positivism, post-positivism, critical theory, and constructivism. McNabb (2017) argued that interpretive and critical paradigms are prominent in the qualitative approach (Mkansi and Acheampong, 2012).

A research paradigm contains detailed philosophical assumptions guiding the researchers' reasoning and actions. For example, a research paradigm was developed in the eighteenth century when rational thoughts and reasons were substituted by religion and faith to explain phenomena. That research paradigm is called positivism (Abu-Alhaija, 2019). Conversely, constructivism is defined as the complexity of views rather than opinionated meanings in a few themes or ideas. Constructivism aims to determine perspectives and subjective meanings within social contexts and is dependent on the opinions of those being researched (Bongna et al., 2020). Meanwhile, transformativism is a research paradigm that studies reality as socially constructed in human consciousness rather than objectively existing outside the human experience (Leach Sankofa, 2021). Finally, pragmatism is regarding "*what works*". The pragmatism research paradigm focuses on solving practical concerns in the world instead of being constructed on beliefs about the nature of knowledge (Maarouf, 2019).

4.1.1 Pragmatism research paradigm

The research study herein has adopted the pragmatism research paradigm. The approach attempts to harmonise both facts and values; captures the reality of the situation (i.e., consequences of ideas); and focuses on problems, applications, and relevance. The purpose of adopting pragmatism is because it considers concepts, hypotheses, and research outcomes in terms of practical consequences in specific contexts. For a pragmatist, reality matters. For them, research starts with a problem and aims to contribute to research with a practical solution. According to pragmatist research, the most important determinant of research design and strategy would be a research problem that tries to address the research question (Thornhill et al., 2009). Pragmatism means action, and it was derived from the Greek word 'pragma'. The words 'practice' and 'practical' are derived from pragma. In 1878, Charles Sanders Peirce introduced the concept of pragmatism in the article "*How to make our ideas clear*" (Dewey, 1916) that was later developed by other researchers (James, 1975; Pansiri, 2005).

The foundation of pragmatism is based on determining the practical use of any thought or idea. Pragmatism contradicts a few basic ideas of earlier philosophies, most notably the Cartesian philosophy. The cartesian philosophy assumes that one may only reach the truth if one begins from the premises, which is unavoidable. However, pragmatists have contrasting views. A pragmatist states that one can identify and eliminate errors by further discussion and investigation. Moreover, given the contextual nature of qualitative research, pragmatism emphasises probabilities more than fixed beliefs, which is an attractive attribute to be explored. Various philosophers have given different explanations of pragmatism. For example, Peirce (1878) mentioned pragmatism as a method to clarify the meaning of specific concepts, ideas, thoughts, or opinions by studying their potential relationship with the real world using scientific logic. According to Peirce, a person must not simply familiarise oneself with the concepts, but they should also define them. A text/statement/sentence can be considered meaningful only when the derived practical and experimental consequences generate potential ideas and concepts as practical outcomes (Hannes and Lockwood, 2011).

Scheffler (1974) mentioned pragmatism as a philosophy that discusses the consequences of beliefs, particularly the effect of moral and religious questions on individuals. Peirce's point of view is that an investigator should understand the truth and form an opinion. World-renowned philosopher and psychologist John Dewey referred to the theory of pragmatism as experimentalism or instrumentalism (Biesta and Burbules, 2003 and Hickman and Alexander, 1998). John Dewey explained that "*philosophy should take the methods and insights of modern science into account*"—pragmatism was linked to concepts of inquiry by Peirce and Dewey.

However, the definition of inquiry was different for both of them. According to Peirce, "*Inquiry, when properly conducted, is the process of attempting to arrive at a belief that would never occasion doubt, a belief that would not give rise to recalcitrant experiences*" (Talisse and Aikin, 2008, p. 20). Whereas Dewey's views on inquiry is "*Inquiry is the controlled or directed transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole*" (Riga, 2020, p. 229).

4.3 Research design

Research design is considered a road map for research investigation to answer the research questions. Creswell (2014) called it the procedures of the query. It reflects the strategies and techniques used to achieve research objectives (Abu-Alhaija, 2019). According to Sekaran and Bougie (2016), Cooper and Schindler (2014), and Creswell (2014), research design explains several parameters, such as research purpose, sampling strategy, timeline, data collection and analysis. Yin (2011) described research design as "*logical blueprints*", i.e., linking the research question, the data to be collected and approaches to analyse the data, which will help address the research questions through the study's findings. The research design also helps in strengthening the research validity and its accuracy. However, there is no exact blueprint for research design.

Cooper and Schindler (2014) suggested four stages in a research study. The first stage is developing a research design, which defines the data collection technique, sampling design and pilot testing. In the second stage, the data collection process is explained. The third stage determines the data analysis as well as interpretation. The final stage refers to the reporting of research results. The first stage of the research study can affect the remaining stages. Therefore, a researcher needs to choose an appropriate research design.

The research study adopted a qualitative method and used interviews as a strategy to collect the empirical data. The interview strategy was considered primarily due to the strength of answering ‘how’, ‘when’ and ‘what’ questions and providing an in-depth and rich understanding of the entrepreneurial pivoting phenomenon. In addition, structured interviews were performed to extract comparable findings with respect to the literature review. The study interviewed tech entrepreneurs across the UK to understand their tech startup’s journey through pivoting as well as the impact of technology maturity on the entrepreneurial journey.

4.4 Qualitative research method

Busenitz et al. (2013) mentioned that for an improved research outcome, an extensive literature review and a thorough research methodology are essential. Researchers in the field of entrepreneurship employ both quantitative and qualitative methods, however, quantitative research method tends to dominate in the extant literature (Gartner 2001; Ucbasaran et al., 2001; and Busentiz et al. 2003). A few researchers, such as Gartner and Birley (2003) and Hindle (2004) have stressed that critical questions can also be addressed by qualitative techniques in the entrepreneurship research field. However, the quantitative technique is more relevant for asking “*how many, how often or causal relationships between variables*”. In qualitative research, open-ended questions like why, what, and how can be used to explore and understand the experience (Molina-Azorín et al. 2012).

Onwuegbuzie (2004) explained that responses are primarily in textual format in qualitative methods, and they are analysed using qualitative techniques. Whereas in a quantitative study, the data is in a numerical format and analysed using quantitative methods. The qualitative technique studies the behavioural aspects of research and helps to view and develop a holistic understanding of the process in a specific scenario. Whereas the quantitative technique helps establish the cause-and-effect relationship and deduct findings from a sample of populations

(Molina-Azorín et al., 2012). A study reviewing 2,649 articles illustrated that although qualitative-quantitative studies (collecting the data in the qualitative method and later converting the data into numbers for conducting quantitative analysis) are utilised in disciplines such as social sciences, it is infrequent in management disciplines (Trumbo, 2004).

Scholars such as Glaser and Strauss (2017) as well as Charmaz (2009) and Suddaby (2010) have traditionally employed qualitative methods to generate new theories and impose conceptual order on the new or relatively undefined phenomenon. Grounded theory is a systematic research method that structures collected data and provides detailed analysis techniques. The defining purpose of grounded theory is to develop a theory that offers a conceptual understanding of one or more core concepts in the specific study (Charmaz and Thornberg, 2021; Chun Tie et al., 2019). Similarly, Vollstedt and Rezat (2019, p. 82) have characterised grounded theory as a methodology which is "*an iterative process and interrelatedness of planning of data collection, data analysis and theory development.*"

The foremost objective of grounded theory is to enable the discovery and evolution of new conceptual categories not contaminated by theories and more suited to diverse disciplines. However, there has always been a debate about whether original intent can be achieved by grounded theory or not. Indeed, Eisenhardt (1989) explained that grounded theory in qualitative methods has the potential for generating new empirically based theories. Furthermore, entrepreneurship research has often been criticised for having an excessive reliance on quantitative methods and a positivist thinking approach to studying a phenomenon (Churchill, 1992; Aldrich, 2003; and Gartner and Birley, 2002).

In order to present new insights and build theories, open-ended questions should be asked by the qualitative researcher while remaining discreetly associated with the phenomenon of the study. To support the above argument, Suddaby et al. (2015) conducted a study to understand the entrepreneurial opportunities through the lens of the qualitative method. The study discussed various factors affecting entrepreneurial opportunities, such as networking, emotions and failures. The researchers understood those factors due to the utilisation of the qualitative method and not through adopting the quantitative method.

The qualitative research method helps in understanding the complexity of the entrepreneurial strategy. Gartner and Birley (2002) mentioned that quantitative studies are numbers–counts, accumulations, averages, and deviations. For the most part, the quantitative research approach is standardised and acknowledged as the recognised standard for how academic scholars decide whether the finding is valid rather than through examining opinion on the phenomenon. Their study explained that the entrepreneurial process involves recognising and understanding the behaviour of entrepreneurs, and numbers do not necessarily add up to illustrate the experience of individuals/entrepreneurs. Therefore, qualitative, and quantitative research methodologies can be adopted to study entrepreneurship. However, through quantitative studies, one may not simply ask certain open-ended questions for which qualitative research studies may be best served. The qualitative approach helps in both ways, asking questions about the phenomenon studied and probing the data to understand how those questions are addressed. Lincoln and Denzin (2011), Dey (1999) and Strauss and Corbin (1998) mentioned in their studies that there are a variety of modes to question and answer ideas, approaches, and experiences in qualitative research.

4.4.1 Grounded theory

Barney Glaser and Anselm Strauss proposed the *Grounded Theory* in 1967. The researchers defined grounded theory as an innovative method used to develop new theories based on empirical data analysis (Glaser and Strauss, 1967). The grounded theory consists of unique methodological aspects, for example, comparative analysis and theoretical sampling. The grounded theory bridges the void between theory and empirical research by providing practical guidelines to develop new theories relating to social processes from raw qualitative data. Walker and Myrick (2006) defined grounded theory as a pioneering research approach because it blends the depth and richness of qualitative interpretive traditions with the logic, rigour, and systematic analysis inherent in quantitative survey research. Payne (2007) explained that grounded theory has gained much attention in recent decades in qualitative research. The theory is popular in various domains; from understanding the software development process (Cole and O'Connor, 2007) to studying beer consumption (Lee, 2006) as well as research on intercultural friendships (Pettigrew, 2002). Moreover, it is widely used in healthcare research, such as nursing, including the work of Artinian et al. (2009), and Coyne and Cowley (2006). McCann and Clark (2003a) argued that grounded theory is an effective research technique for topics subject to relatively little research and a lack of knowledge (Dunne, 2011).

A defining characteristic of grounded theory is that it seeks to develop a theory that is grounded in the data. Consequently, grounded theory has several distinct methodological genres: traditional grounded theory is associated with Glaser; an evolved grounded theory is associated with Strauss, Corbin, and Clarke, while constructivist grounded theory is associated with Charmaz and Bryant. Constructivist grounded theory is an extension and development of the original grounded theory developed by Glaser and Strauss. The goal of traditional grounded theory is to generate a conceptual theory that accounts for a relevant and problematic pattern for those involved. The evolved grounded theory, a second genre, is established on symbolic interactionism. Symbolic interactionism is a sociological perspective that relies on people's symbolic meaning during social interaction processes. The second genre discourses the subjective meaning of people, place, objects, behaviours, or events based on what they consider is true (Chamberlain-Salaun 2013). The third and final genre is the constructivist grounded theory developed and illustrated by Charmaz (2006), which has its roots in constructivism. The constructivist grounded theory focuses on how participants' construct meaning concerning the area of inquiry, and a constructivist co-constructs experience and meanings with participants (Charmaz and Bryant, 2011). While there are commonalities across all the genres of grounded theory, there are factors that distinguish differences between the approaches, including the researcher's philosophical position, the use of literature, and the approach to coding, analysis, and theory development (Tie et al., 2019).

Historically, grounded theory is considered a rigorous and qualitative technique that comprises a set of fundamental procedures to design a theory or explain a social-psychological process (Gutterman et al., 2019). The scientific canons of the grounded theory include significance, theory-observation compatibility, generalizability, consistency, reproducibility, precision, and verification. The grounded theory procedures are developed to generate a well-integrated set of concepts from the theoretical explanation of social phenomena. Pragmatism and symbolic interactionism are the pillars of grounded theory. Although a researcher does not need to support these philosophical and sociological orientations to use the theory, two essential principles of grounded theory are built on them. The two important principles of grounded theory are change and determinism. Since phenomena are not perceived as constant but as incessantly changing due to evolving conditions, it is vital to foster change, through the process, into the method. By contrast, extreme determinism is rejected. Both pragmatism and symbolic interactionism underpin this perspective. Therefore, grounded theory aims to find relevant experiences and determine how the participants in the study respond to changing circumstances and the outcomes of their actions. The above two principles make the grounded theory suitable for both microscopic or macroscopic study (Corbin and Strauss, 1990).

4.5 Data collection

The data for qualitative research can be collected from different sources. The process starts with collecting materials through various methods, such as interviews, case studies, records, documents (such as audio, video, and text files) and basically anything that may shed light on questions under study (Corbin and Strauss, 1990; and Bailey, 2008). In this research study, data has been collected in two ways and Figure 17 depicts the data collection process. Initially, at the beginning of the data collection stage, secondary data was collected to provide an initial understanding of the types of pivots pursued by technology companies and the associated factors. Thereafter, primary data was collected through conducting interviews with high-tech entrepreneurs from across the UK to provide the empirical heart of the research study.

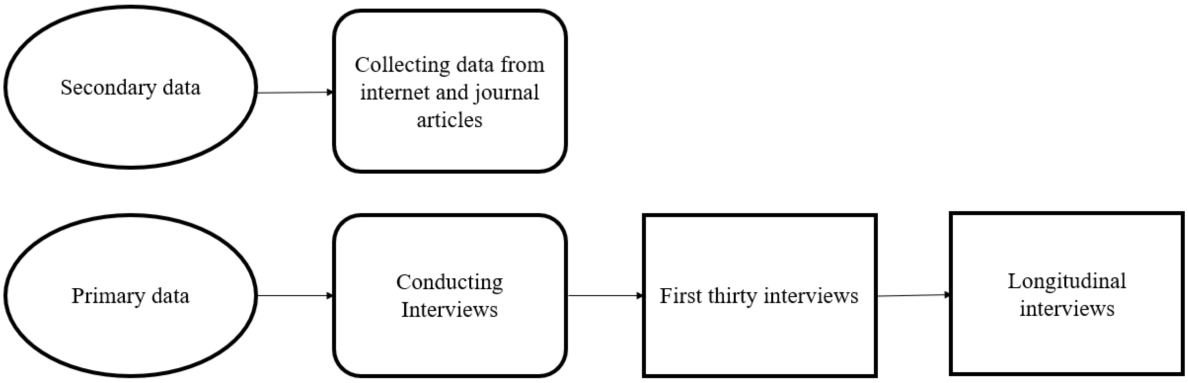

Figure 17. Data collection scheme employed in the research study.

4.5.1 Secondary data

This research study aims to validate the type of pivots pursued by startup companies and the factors that trigger such pivots. In order to address this objective, secondary data has been collected from various academic journals and company websites. Secondary data is a dataset that a researcher does not collect by him/herself but instead analyses existing data (Martin et al., 2018). The benefits of using secondary data are eliminating financial and logistical obstacles while collecting primary data (Trinh, 2018). However, certain precautions must be taken. A researcher should elucidate the limitations using secondary data and explain the actions taken to use the original data set for the new research gap. The secondary data should be conscientiously interpreted to generate a hypothesis and not prove the hypothesis (Martin et al., 2018; Trinh, 2018).

As part of the secondary data collection, academic articles of Bajwa et al. (2017), Comberg et al. (2014) and Terho et al. (2015) were reviewed to understand in greater detail the different types of pivots and the possible factors behind pursuing those pivots. At the same time, the study involved searching the internet to identify examples where technology startups/companies have pivoted. Examples of the search keywords used in the internet search are as follows: 'business pivots', 'pivots by startups', 'famous business pivots', and 'pivots'. While looking for such data, the study focused only on tech startup companies to understand what type of pivots they pursued. The intention behind collecting the secondary data was to understand what type of pivots have been pursued by technology startup companies. The secondary data was collected from multiple sources (principally academic articles and different websites out of which roughly 60% was collected from Bajwa et al. (2017); 10% was from Comberg et al. (2014); Terho et al. (2015) and Hirvikoski (2014); and the remaining 30% was from the Internet (different websites searched in Google) such as Basulto (2015); BusinessNewsWales (2020); ChannelSight (2020); Glaveski (2018); Gebel (2019); Hinchliffe (2020); Kumar (2020); Morgan (2020); Nazar (2013); O'Hear and Lomas (2014); Pruitt (2017); Ringle (2017); Superscript (2020) and Woodford (2020). The research study collected data on startup companies from across the globe, including startups from Canada, Finland, France, Germany, India, Ireland, Israel, Japan, Mexico, the Republic of Tunisia, Spain, UK, and USA.

The secondary data revealed what type of pivots tech startups/companies pursue and how successful they are after pivoting. Tech companies, such as Twitter and Facebook, are international examples that pivoted at an early stage of their journey (Hirvikoski, 2014). During data collection, the study identified few websites such as ChannelSight (2020); Kumar (2020); Morgan (2020) and Woodford (2020) that illustrated the startup companies that pivoted to respond the pandemic situation caused due by COVID-19. In this case the study determined the types of pivots those tech startups pursued and labelled the factor causing the pivot as market conditions (due to pandemic). Table 3 provides the details of companies identified in the secondary data capture process that pursued pivots and the factors that trigger pivots.

Table 3. Details of companies that pivoted (from secondary data sources) along with factors that caused the pivoting.

Company	**Factor(s)**	**Pivot(s)**
Company-1	Influence of investor, partner, or founder	Platform pivot
Company-2	Customer feedback	Platform pivot
Company-3	Market conditions (due to pandemic)	Platform pivot
Company-4	Market conditions (due to pandemic)	Value capture pivot
Company-5	Customer feedback	Zoom-in pivot
Company-6	Unscalable business	Customer need pivot
Company-7	Flawed business model	Zoom-out pivot
Company-8	Influence of investor, partner, or founder, flawed business model, market conditions, business financials and technology challenges	Customer segment pivot, business architecture pivot, value capture pivot and engine of growth pivot
Company-9	Customer feedback	Customer need pivot
Company-10	Unscalable business	Customer need pivot
Company-11	Legal issue	Complete pivot

Company	Factor(s)	Pivot(s)
Company-12	Wrong timing and unscalable business	Customer need pivot
Company-13	Flawed business model	Customer segment pivot
Company-14	Influence of investor, partner, or founder, flawed business model, market conditions, business financials and technology challenges	Customer segment pivot, channel pivot, engine of growth pivot and value capture pivot
Company-15	Unscalable business	Zoom-out pivot
Company-16	Market conditions (due to pandemic)	Value capture pivot
Company-17	Market conditions (due to pandemic)	Complete pivot
Company-18	Customer feedback and flawed business model	Complete pivot
Company-19	Customer feedback	Customer segment pivot
Company-20	Market conditions (due to pandemic)	Customer segment pivot
Company-21	Customer feedback	Zoom-in pivot
Company-22	Market conditions (due to pandemic)	Complete pivot and business architecture pivot
Company-23	Competition	Zoom-in pivot
Company-24	Side project success	Side project pivot
Company-25	Market conditions (due to pandemic)	Platform pivot
Company-26	Customer feedback and flawed business model	Customer need pivot and customer segment pivot
Company-27	Side project success	Side project pivot
Company-28	Market conditions (due to pandemic)	Market segment pivot
Company-29	Unscalable business	Customer need pivot
Company-30	Market conditions	Business architecture pivot

Company	Factor(s)	Pivot(s)
	(due to pandemic)	
Company-31	Flawed business model, technology challenges and unscalable business	Zoom-out pivot, platform pivot, customer segment pivot, channel pivot and business architecture pivot
Company-32	Customer feedback	Market segment pivot
Company-33	Market conditions (due to pandemic)	Customer need pivot
Company-34	Customer feedback	Zoom-in pivot
Company-35	Customer feedback	Customer need pivot
Company-36	Market conditions (due to pandemic)	Market segment pivot
Company-37	Customer feedback	Customer segment pivot
Company-38	Market conditions (due to pandemic)	Customer need pivot
Company-39	Market conditions (due to pandemic)	Side project pivot
Company-40	Side project success	Side project pivot
Company-41	Influence of investor, partner, or founder, flawed business model, market conditions and technology challenges	Technology pivot, channel pivot, engine of growth pivot and value capture pivot
Company-42	Market conditions (due to pandemic)	Business architecture pivot
Company-43	Unscalable business and technology challenges	Zoom-in pivot, Zoom-out pivot and technology pivot
Company-44	Unscalable business and customer feedback	Complete pivot and customer need pivot
Company-45	Technology challenges	Technology pivot
Company-46	Flawed business model	Customer need pivot
Company-47	Unscalable business	Complete pivot
Company-48	Influence of investor, partner, or founder	Complete pivot

Company	Factor(s)	Pivot(s)
Company-49	Influence of investor, partner, or founder and side project success	Side project pivot
Company-50	Influence of investor, partner, or founder	Customer need pivot
Company-51	Market conditions (due to pandemic)	Platform pivot
Company-52	Customer feedback and wrong timing	Zoom-in pivot
Company-53	Customer feedback, unscalable business and competition	Complete pivot
Company-54	Customer feedback	Complete pivot
Company-55	Customer feedback	Zoom-in pivot
Company-56	Competition	Customer need pivot
Company-57	Customer feedback and influence of investor, partner, or founder	Channel pivot
Company-58	Customer feedback	Zoom-in pivot
Company-59	Customer feedback	Customer segment pivot
Company-60	Influence of investor, partner, or founder, flawed business model and business financials	Customer segment pivot, value capture pivot and engine of growth pivot
Company-61	Influence of investor, partner, or founder	Complete pivot
Company-62	Unscalable business	Platform pivot
Company-63	Technology challenges	Platform pivot
Company-64	Flawed business model, business financials and marker conditions	Zoom-in pivot, Zoom-out pivot, customer segment pivot and business architecture pivot
Company-65	Unscalable business and customer feedback	Customer need pivot
Company-66	Influence of investors, partners, or founders	Side project pivot
Company-67	Unscalable business	Complete pivot
Company-68	Competition	Complete pivot

Company	Factor(s)	Pivot(s)
Company-69	Customer feedback	Customer need pivot
Company-70	Customer feedback	Zoom-in pivot
Company-71	Market conditions (due to pandemic)	Side project pivot
Company-72	Market conditions	Value capture pivot
Company-73	Technology challenges	Technology pivot and customer need pivot
Company-74	Customer feedback (positive)	Complete pivot
Company-75	Technology challenges	Technology pivot and customer need pivot
Company-76	Customer feedback (positive)	Customer need pivot
Company-77	Market conditions (due to pandemic)	Value capture pivot
Company-78	Market conditions (due to pandemic)	Platform pivot
Company-79	Customer feedback and wrong timing	Customer need pivot
Company-80	Side project success	Side project pivot and customer segment pivot

4.5.2 Primary data

4.5.2.1 First thirty interviews

To collect the primary data the study involved approaching tech entrepreneurs across the UK through social networking sites such as LinkedIn, Twitter, and Facebook to ask whether they would be interested in being interviewed. Nearly forty tech entrepreneurs showed interest in the research study, and thirty agreed to the interview. Although two participants were not tech entrepreneurs, they worked in several tech startups as strategic heads and finance heads of the startups, and subsequently had experience of pivoting.

Appendices I, II, and III provide respectively the research invitation to participants; participant information sheet; and participant consent form, shared with the participants before conducting interviews. The duration of the interviews was scheduled for 45-50 minutes and had 17 questions to capture the participant's experience of entrepreneurial pivoting and the impact of technology. The questions were designed to align with the research study's objectives, and the data collected through interviews helps to address the research questions. The interviews aimed at collecting data to understand participants' entrepreneurship experience; their tech startup's pivoting journey; factors behind those pivots; the influence of TE phases; and the impact of technology S-curve stages. The questionnaire for the first thirty interviews is provided in Appendix IV.

Descriptive statistical data of the participants is presented in Table 4. Table 4 illustrates the tech entrepreneur's details, such as overall professional experience as a tech entrepreneur, under which category of BVCA their startups fall, and the number of times their startup pivoted. In order to maintain confidentiality, the study assigned IDs to each tech entrepreneur, and the same IDs will be used throughout the research study to analyse and explain their entrepreneurial pivoting experience.

Table 4. Details of participants who were interviewed in the study.

Participant-ID	**Technology sector category**	**Gender**	**Role in tech startup**	**Experience (in years)**	**No. of tech startups launched**
Participant-1	Other electronics related technology	Male	CEO	20-30	6
Participant-2	Software technology	Male	CEO	10-20	3
Participant-3	Other electronics related technology	Male	CTO	1-5	1
Participant-4	Software technology	Male	CEO	1-5	2
Participant-5	Biotechnology, medical, instrumentation and	Male	CEO	1-5	1

	medical pharmaceutical technology				
Participant-6	Internet technology	Male	CEO	10-20	1
Participant-7	Software technology	Female	CEO	1-5	1
Participant-8	Internet technology	Male	CEO	5-10	3
Participant-9	Software technology	Male	CEO	10-20	3
Participant-10	Software technology	Female	CEO	1-5	1
Participant-11	Software technology	Male	CEO	1-5	1
Participant-12	Software technology	Male	CEO	1-5	1
Participant-13	Internet technology	Male	Advisor	30 years plus	2
Participant-14	Software technology	Female	CEO	1-5	2
Participant-15	Internet technology	Male	CEO	5-10	1
Participant-16	Internet technology	Female	CEO	1-5	1
Participant-17	Internet technology	Male	CEO	10-20	2
Participant-18	Other electronics related technology	Male	CEO	10-20	3
Participant-19	Communication Systems	Male	CEO	5-10	10
Participant-20	Internet Technology	Male	CEO	1-5	2
Participant-21	Software Technology	Male	CEO	1-5	1
Participant-22	Internet Technology	Male	CEO	1-5	1
Participant-23	Other electronics related technology	Female	CEO	10-20	1
Participant-24	Communication Systems	Male	CEO	10-20	3
Participant-25	Biotechnology, medical, instrumentation and medical pharmaceutical technology	Male	CEO	1-5	1
Participant-26	Biotechnology, medical, instrumentation and medical pharmaceutical technology	Female	CTO	1-5	1
Participant-27	Internet technology	Male	CEO	10-20	1
Participant-28	Other electronics related technology	Male	Advisor	30 years plus	3
Participant-29	Internet technology	Male	CEO	1-5	1
Participant-30	Biotechnology, medical, instrumentation and medical pharmaceutical technology	Male	CEO	1-5	1

Out of the thirty tech entrepreneurs, ten participants use AI technology as their core technology; five participants use Python, a computer language for coding and writing programs; four participants use blockchain technology; and another four participants use biomedical technology such as genetic engineering as a core technology. Three participants use Amazon Web Services™ as a core technology. The remaining four participants work on ultrasonics, drone technology, quantum computing and digital communication.

4.5.2.2 Longitudinal interviews

Longitudinal research analysis involves the comparison of data across different time periods. Longitudinal interviews are conducted with the same group of participants (i.e., interviewees) over a period of time, thereby allowing the researcher to collect data on specified changed conditions (Hermanowicz, 2013). The researcher discussed the motivation behind longitudinal research study, i.e., it helps researchers understand what they can learn by following participants over a period during their professional lives.

A primary concern in longitudinal qualitative studies is how many interviews should be conducted and at what frequency. Saldana (2003) explained that the number and frequency of interviews in a longitudinal study will depend on the research problem. Therefore, it will vary from study to study (cited in Hermanowicz, 2013). Furthermore, Hermanowicz (2013) mentioned that the number and frequency should be determined based on the time that is required to examine relevant transformations from one point to another.

The interviewees were asked to participate in longitudinal interviews to provide further detailed insights and data. The longitudinal interviews focused on collecting more detailed information to understand why the situation that resulted in pivoting by the startup had arisen. The longitudinal interviews were subdivided into three stages for collecting in-depth information regarding the tech startup's journey from August 2020 to May 2021. The study had already collected data in the form of the first thirty interviews. Since technology development in tech startups is very rapid, it was decided to conduct the interviews within a year as it was a sufficient time period. Ten high-tech entrepreneurs from the thirty tech entrepreneurs agreed to longitudinal interviews. After the first stage of interviews, one participant did not wish to continue, leaving nine interviewees to participate in the longitudinal study. The nine interviewees are participants 2, 4, 9, 14, 16, 17, 18, 26 and 29.

The first round of interviews was conducted from September 2020 to October 2020. This round focused on gathering information on the tech startup's performance since the beginning of COVID-19 and any pivoting possibility due to the pandemic. The second round of interviews was held from December 2020 to January 2021 and focused on understanding how things have changed in the last four months due to the pandemic and to understand the experience of tech entrepreneurs concerning the domino effect in pivoting, the types of pivots that can be pursued at a particular phase of TE and at a certain stage of the technology S-curve. The third and final round of interviews aimed to understand what leadership qualities the tech entrepreneurs possess and whether TRL (technology readiness level) of the startup's main technology can influence pivoting. These interviews were performed from March 2021 to May 2021.

4.5.3 Data Saturation

In a qualitative research study, the data is analysed by coding the interview transcripts to identify themes and systematically categorising them into concepts. Determining whether the data have been sufficiently collected is one of the critical aspects of gathering qualitative data (Mwita, 2022). Researchers can stop collecting data once they achieve data saturation as it accomplishes the intended research objectives (Fusch et al., 2018).

Glaser and Strauss (1967) defined data saturation in grounded theory. Data saturation means that a qualitative researcher finds no more new properties of the category by further collecting the data. Therefore, data saturation is a criterion for concluding data collection and analysis (cited in Saunders et al., 2018). The researchers explained four data saturation models and their centre on interest in the research process. Firstly, the theoretical saturation model is related to grounded theory, and its principal focus is sampling—secondly, the inductive thematic saturation model is associated with the emergence of new codes/themes. The principal focus is data analysis. The third model is called prior thematic saturation. This model relates to how recognised codes or themes are illustrated in the data. The principal focus is on data sampling. The final model is called data saturation, which describes how new data repeat what was depicted in previous data. The principal focus is on data collection.

Theoretical saturation, defined under grounded theory, is achieved when a qualitative researcher observes similar instances of a category or categories repeatedly. This research study follows the grounded theory. Therefore, the research followed theoretical saturation as a basis for reaching data saturation. After conducting the primary thirty interviews, during the first coding cycle, the researcher observed the instances of theoretical saturation with respect to validating the types of pivots and the factors that trigger the pivoting. Similarly, during longitudinal interviews, the researcher identified repeating instances of similar themes/patterns related to the categorisation of pivots by domino effect, phases of technology entrepreneurship and stages of technology S-curve.

Mwita (2022) conducted a systematic literature review of twenty-four journal articles published between 2018 and 2022 to understand data saturation in qualitative research studies. The study identified that the relevance of research subjects is one of the critical factors in obtaining the intended data, and all twenty-four articles used non-probability sampling to collect data. The researcher explained studies which incorporated relevant respondents have more probability of reaching a saturation point than those that did not. Additionally, Mwita's study pointed out that out of twenty-four reviewed journal articles, twenty-one opted for purposive sampling, which is a non-probability sampling technique. The research study, opted purposive sampling technique to identify the relevant participants for collecting data on the types of pivots, factors that trigger pivots, and the domino effect in pivots, and to evaluate the impact of TE phases and the influence of stages of technology S-curve on pivoting.

4.6 Data analysis

Grounded theory has specific data collection and analysis procedures, although flexibility and latitude are within limits. Corbin and Strauss (1990) suggested that *"data collection and analysis are interrelated processes"*. In grounded theory, the analysis begins as soon as the first piece of data is collected. Unfortunately, many qualitative researchers gather much data before starting the systematic analysis. While it may work for other modes of qualitative research, this potentially violates the foundations of the grounded theory method.

Nevertheless, this analysis at the beginning is necessary because it helps direct the subsequent interview phases and observations. Each researcher starts collecting data by asking questions in the interviews or collecting materials by observing the field (Corbin and Strauss, 1990). According to Halcomb and Davidson (2006), based on structure, flexibility, and interviewer/ interviewee interaction pattern, interviews can be distinguished from a purely quantitative approach to a qualitative one.

Data is collected on these matters throughout the research endeavour unless the questions prove, during analysis, to be irrelevant. To not miss anything that may be salient, the researcher must conduct a preliminary data analysis to identify cues. Then, all other relevant issues missed in the initial discussion must be included in the following interviews and observations. Systematically and sequentially, data collection and analysis processes enable the research method to capture all potentially pertinent elements of the topic as soon as they are recognised (Glaser and Strauss, 1967). This process forms a significant basis of the effectiveness of the grounded theory approach. The research process directs the researcher toward studying all possibly rewarding routes to understanding. Therefore, the research method is one that grounds a theory in reality (Corbin and Strauss, 1990).

Each concept brought into the study or uncovered in the research process is initially considered provisional. However, every idea/experience/concept makes its way into the theory by frequently being present in interviews, documents, and observations in one form or another. The grounded theory helps guard against researcher bias while evolving a concept (i.e., as an action or consequence) as a theory. No matter how fascinated the researcher may be by a specific concept, it must be discarded if its relevance to the phenomenon is not proven through continued scrutiny. Grounding concepts in the reality of data thus gives this method theory-observation congruence or compatibility (Corbin and Strauss, 1990).

4.6.1 Transcribing the data

In grounded theory, "*concepts are the basic units of analysis*" (Corbin and Strauss, 1990, p. 7). A researcher works with conceptualisations of data, not the actual data per se. Theories cannot be constructed with actual incidents or activities as observed or documented; that is, from raw data. Instead, the incidents, events, and experiences are taken as or analysed as potential phenomena indicators, thereby giving conceptual labels. Additionally, by comparing incidents and naming like phenomena with the same term, a researcher can accumulate the basic units for theory. In the grounded theory approach, such concepts become more numerous and abstract as the analysis continues (Corbin and Strauss, 1990). Numerous qualitative studies collect audio or video data (e.g., recordings of interviews, focus groups, or talk in consultation), which are usually transcribed into written form for closer study. Transcribing seems to be a straightforward technical task. However, the fact is that it involves many judgements about what level of detail to select (e.g., skipping non-verbal interaction), data interpretation (e.g., differentiating ‘no’ from ‘know’ or ‘don’t’ from ‘do not’) and data representation (e.g., representing the verbalisation ‘hwarryuhh’ as ‘How are you?’). The first step in analysing data is transcribing audible and visual data into a written format, an interpretive process (Bailey, 2008; Davidson, 2009).

Transcribing is usually done by the researcher because transcription involves close observation of data through repeated and attentive listening. It is an essential first step in data analysis as this step familiarises the researcher with the qualitative data and helps understand what is there rather than what is expected. In addition, this process can facilitate realisations or ideas that emerge during analysis (Pope and Mays, 2000; Silverman, 2013). Transcribing often takes a long time, at least 3 hours per hour of interview audio talking and even up to 10 hours per hour with an acceptable level of detail, including visual detail (Have, 1999), and therefore this should be adequately allowed for in project schedules. For this research study, fifty-seven interviews were conducted (initially 30 interviews, followed by three rounds of 9 interviews each as part of the longitudinal part of the study), and all of them were transcribed for data analysis. Each of the first set of thirty interviews lasted for 45-50 minutes on average, and it took close to 2.5-3 hours to transcribe each one of them. In the case of the longitudinal interviews, i.e., the subsequent twenty-seven interviews lasted on average for 30 minutes each. To transcribe each longitudinal interview, it took close to two hours. Every interview was transcribed at least twice in order to familiarise the context and to conduct rigorous data interpretation as well as data representation.

Written language is represented in standardised ways that are different from audible speech. For example, ‘pivot one and three’ is much more easily read and understood if represented as separate words, with punctuation and capital letters, such as: ‘Pivot one (zoom-in pivot) and pivot three (technology pivot)’. Using the grammar and spelling conventions of standard written English helps readability and irons out the linguistic variety, which is an important cultural and subcultural identity feature (Britten et al., 1995). Another example would be during the interview process, participants often make sounds such as ‘ummm’ or ‘hmmm’. Omitting those expressions will bring much more clarity to the transcriptions. Thus, eliminating repetitions, interruptions and overlaps in transcriptions helps avoid cluttering of the text (Roberts, 1997; Tilley, 2003).

Transcriptions reflect the interpretations of researchers. For example, in the transcriptions, a researcher can mention that the participant expressed their dissatisfaction by writing it as the participant is ‘not pleased’ or ‘angry’ or ‘very angry’, and these expressions convey different interpretations (Roberts, 1997; Stuckey, 2014). However, the transcriptions for this research do not contain any such type of expression. Instead, the participants gave answers to the best of their knowledge straightforwardly. For example, when questioned about the type of pivot their tech startup pursued or the factor behind the pivot, participants were able to pinpoint the exact type of pivots and factors. Therefore, the researcher did not need to capture expressions. Presenting quotations in a thesis or research article implicates additional steps in reduction and representation by choosing which text from the data to present and what to emphasise. There is an argument about the relevant context in qualitative research (Wetherell, 2001; Gesler, 1999; Heath, 1998). For example, research studies usually illustrate the backdrop in which data was collected and participants’ demographic features, such as age, gender, professional experience and role. However, relevant contextual information could also include historical, political and policy contexts, such as participants’ physical appearance, recent events, and details of previous interviews. Thus, the decisions by researchers on which data and what contextual information to present will lead to a different data framing (Schegloff, 1997; Bazeley, 2013).

Conversion of visible and audible data into written form is the first step in analysing data, which is an interpretive process rather than simply a technical procedure involving making decisions. There are different ways to transcribe the data, and researchers need to decide which level of transcription detail is needed for their research study and how data can be described in written form. In addition, the close observation of data while transcribing can lead to detecting unanticipated phenomena. Furthermore, it is impossible to portray the full complexness of human interaction on a transcript. Therefore, listening to and watching the recorded data helps to understand how things have been communicated and what has been expressed (Maclean et al., 2004; Bailey, 2008; Creswell and Poth, 2016; Azevedo et al., 2017).

4.6.2 First cycle of coding

Saldana (2013, p. 58) explained the coding procedure analogous to a theatre production works, where a saying goes, "*plays are not written, they are rewritten*." Similarly, for qualitative researchers, "*data is not coded, they are recoded.*" Codes are often improved in studies from time to time, and some methodologists termed them 'stages', 'levels' or 'feedback loops'. According to Saldana (2013), the qualitative analytical approach is cyclical instead of linear because of the constant comparison between 'data to data', 'data to code', 'code to code', 'code to category', 'category to category', and 'category to back to data'.

Under the first coding cycle, there are seven subcategories, namely: affective, elementary, exploratory, grammatical, literary and language, procedural, and theming of the data. Each subcategory has its own coding characteristics, and a qualitative researcher can choose any one of the methods or multiple coding methods. The second coding cycle consists of six subcategories, namely: axial, elaborative, focused, longitudinal, pattern and theoretical coding (Saldana, 2013).

Patton (2002) suggested that every qualitative research study is distinctive. Therefore, the analytical approach for that research will be unique. Saldana (2013) expressed the view that no one can claim their approach is the best method to code qualitative data. A qualitative researcher may choose one or more coding methods depending on the nature of the study, aim and objectives of the research. Trede and Higgs (2009) agreed that research questions embed the direction of study. Therefore, they influence the type of coding choices a researcher makes. For example, Trede and Higgs (2009) explained that ontological questions address the nature of participants' facts. Hence, the aligned research questions may start with: "*what is the nature of...?*", "*what is the lived experience...?*" and "*what is it like being...?*". These questions indicate the investigation of personal and interpretive intentions within the data. Furthermore, some researchers suggested coding methods for these ontological studies include in vivo process or focused coding.

Saldana (2013) discussed general principles, factors and additional criteria that may influence a qualitative researcher's coding method(s) choice, which are as follows.

1. Every qualitative research study is unique. Therefore, the analytical approach will be unique.
2. A qualitative researcher has the freedom to develop a new coding method, or choose one or more existing methods, or use a combination of coding methods.
3. The researcher should keep themselves open during the initial data collection and re-examine the coding method selected for the study.
4. The coding method depends on the nature, aim and objectives of the research study and the form of data. A researcher may find that one coding method is sufficient; other

times, two or more coding methods are required to capture the details of complex phenomena.

5. Data is not coded, they are recoded. The qualitative researcher should be willing to change the coding techniques if the initial approaches are not functioning properly.
6. While analysing the coding data, the study should experience progress during identification of new findings, insights, and connections with the research question(s).

Corbin and Strauss, (1990) defined coding as the fundamental analytical process used by the researcher. Indeed, there are three basic types of coding in grounded theory research, namely: open, axial, and selective. Saldana (2013) referred to open coding as initial coding. Whereas Strauss and Corbin (1998) defined initial (i.e., open) coding as the interpretive process by which qualitative data is broken down analytically. Its purpose is to give the researcher new insights by breaking through standard ways of thinking about or interpreting phenomena reflected in the data. A series of techniques have been developed to further this process. In initial coding, events/actions/interactions are compared with others for similarities and differences. They are also given conceptual labels. This way, conceptually similar events/actions/interactions are grouped to form categories and subcategories. Initial coding stimulates generative and comparative questions to guide the researcher upon return to the field. Moreover, initial coding and its use of questioning and constant comparisons enable investigators to break through subjectivity and bias. This coding method aims to remain open-minded to all potential theoretical approaches from qualitative data analysis (Chramaz, 2006; Glaser, 1978). The initial coding is suited for almost all qualitative studies, particularly for qualitative researchers who are beginners and learning to code. Furthermore, Chramaz (2006) advised that the initial coding method is more appropriate for interview transcripts than research-generated field notes.

Strauss and Corbin (1998) advised that at least ten interviews or observations with detailed coding are necessary for building a grounded theory. Conversely, Saldana (2013) pointed out that methodologists suggested that a minimum of twenty, thirty or even forty separate interviews need to be conducted to build a grounded theory. This study conducted fifty-seven separate interviews, of which twenty-seven are longitudinal.

4.6.2.1 Post-first cycle of coding

Corbin and Strauss (1990, p. 8), mentioned that "*sampling in grounded theory proceeds on theoretical grounds.*" Sampling in grounded theory is not just focused on sampling of specific groups of individuals and units of time but in terms of concepts, their properties, dimensions, and variations. When a research study commences, the researcher introduces some idea of the phenomenon they want to study. Based on this knowledge, groups of individuals, organisations, or community representatives of that phenomenon can be selected for the study (Corbin and Strauss, 1990). MacNealy (1999) distinguished sampling into probability and non-probability techniques. Three non-probability sampling techniques are purposeful, convenience and snowball techniques. The study used the purposive sampling technique to collect data for the research. In purposeful sampling, a researcher will approach participants who possess certain qualities or traits that give various possible perspectives within the specified study (Koerber and McMichael, 2008; Elo et al., 2014). The sampling process ends when information redundancy is achieved. It concludes when all aspects of the phenomenon under investigation are examined and analysed in adequate detail, and no additional information is revealed in succeeding interviews (Cleary et al., 2014; Assarroudi et al., 2018). In grounded theory, the representativeness of concepts, not persons, is essential. The aim is to construct a theoretical explanation by defining phenomena in terms of circumstances that give rise to them, how they are conveyed through action/interaction, the consequences of the action/interaction, and variations of these qualifiers. The aim is not to generalise findings to a broader population per se.

Corbin and Strauss (1990, p. 7) pointed out that "*categories must be developed and related.*" Concepts that pertain to the same phenomenon may be grouped to form categories/themes. However, not all concepts become themes. Categories are higher in level and more abstract than the concepts they represent. Categories are the cornerstones of a developing theory. They indicate how a theory can be incorporated. They are developed through the analytical process of making comparisons to emphasise similarities and differences of events/experiences/ideas. However, merely grouping concepts under a more conceptual heading does not constitute a category. Categories must be developed based on the properties and dimensions of the phenomenon, such as what the concept represents, the conditions, how it is communicated, and the outcomes it produces. Over time, categories can become related to one another to form a theory.

Corbin and Strauss (1990, p. 9) advised that "*analysis makes use of constant comparisons*." As an incident is noted, it should be compared against other incidents for similarities and differences. The resulting concepts are labelled as such, and over time, they are compared and grouped as previously described. Making comparisons assists the researcher in guarding against bias, for them it is then challenging concepts with new data. Such comparisons also help achieve greater precision and consistency (i.e., always grouping like with like).

According to Corbin and Strauss (1990, p. 10) "*patterns and variations must be accounted for.*" The data must be examined for regularity to understand where that regularity is not apparent. They explained that the "*process must be built into the theory.*" In grounded theory, the process has several meanings. Process analysis can mean breaking a phenomenon into stages, phases, or steps.

Finally, Corbin and Strauss (1990, p. 10) suggested that "*writing theoretical memos is an integral part of doing grounded theory.*" Memos are not simply about ideas. They are involved in the formulation and revision of theory during the research process. Writing memos should begin with the first coding sessions and continue to the end of the research study. It should incorporate and elaborate on the coding sessions themselves as well as on the code notes.

4.6.3 Second cycle of coding

The second coding stage is a progressive way of reorganising and reanalysing the coded data from the first cycle. In this stage, the researcher logically links the unrelated facts and compares the categories to "*develop a coherent meta-synthesis*" of the data (Saldana, 2013, p. 207). Before assembling categories, a qualitative researcher may have to recode the data to recognise accurate words or phrases. In addition, the process may involve merging two codes and removing infrequent codes developed during the first coding cycle (Lewins and Silver, 2007). The primary purpose of the second coding cycle is to develop advanced categorical, thematic, conceptual frameworks, and theoretical concepts from the first coding cycle. In other words, the purpose of the second coding cycle is to reduce the number of codes developed in the first coding cycle and develop an array of broader categories, themes, classifications, and concepts (Saldana, 2013).

This study applied the axial coding method in the second coding cycle. Axial coding defines the properties and features of categories. It also explores how the categories relate to subcategories and tests the relationships against data. Subcategories are related to a category through the 'coding paradigm' of conditions, context, strategies (action/interaction), and consequences. Axial coding expands the analytical work from the initial coding method. The goal of the axial coding method is to strategically reconstruct data that were divided or disorganised during the first coding cycle (i.e., initial coding process) (Corbin and Strauss, 1990; Saldana, 2013). Boeije (2010) briefly explained the purpose of axial coding, i.e., to determine which codes are dominant and which are less dominant. This process helps to reorganise and broaden the scope of codes and cross out the redundant codes.

The axial coding approach is suitable for the grounded theory methodology and studies with a wide range of data forms such as interview transcripts, documents, videos, and field notes (Saldana, 2013). In addition, this approach helps to sharpen the codes to achieve their best fit (Glaser, 1978). Another goal of the axial coding method is to attain saturation i.e., no new information, properties, ideas, concepts, or themes emerge from the qualitative data (Strauss and Corbin, 1998).

The domain of social sciences and qualitative data analysis has a long history. Indeed, Saldana (2013), Saunders et al. (2019), and Silverman (2017) are considered guides for researchers in qualitative studies. Two approaches to qualitative data analysis are manual and technological. The manual approach involves analysing the data manually without using any computer software. Whereas the technological approach involves the use of appropriate software (such as NVivo and ATLAS.ti) to code and visualize the data. Qualitative research attempts to understand the experience of individuals that can expand the researcher's conception of reality. A qualitative research study seeks to address questions that start with how and why. The qualitative study is not just analysing text from data. Instead, it is a process of inspecting a practice or system that is socially formed. However, this approach is highly labour intensive for analysing the given volume of datasets (Mattimoe et al., 2021). In this research study, both manual and technological (based on the use of NVivo 12 pro software) approaches were used for the qualitative data analysis. Table 5 summarises the reasons for using manual and technological approaches as well as the challenges and advantages.

Table 5. Challenges and advantages of manual and technological coding approaches.

Characteristic	**Qualitative technique**	
Data analysis approach	*Manual approach*	*Technological approach*
Reason(s) for the selection of approach	• Easy to commence. • Does not need any formal training. • Cost-effective.	• The tool and techniques such as comparison diagrams, matrix coding and cross tab coding are available in the software to analyse the data. • Tools for visualising the data, codes and themes using hierarchy, bar and plotted charts are available. • Availability of a licensed version of the software.
Challenges with the approach	• This can be a time-intensive process as it involves a lot of re-reading and making notes. • Very iterative and sometimes confusing process. • Initial stage of coding is a messy process. • Hard to manage the data.	• The amount of time invested in formal training of the software. • Time gap between learning and implementing the techniques.
Advantages of using the approach	• Enabled an effective understanding crux of the data • Helps in visualising the themes from the data. • Avoids establishing themes or patterns too early.	• Allows coding of the data in a systematic and organised structure. • Flexibility of multiple coding. • A tool for visualising the pattern. • Allows multi-layered analysis of data within less time. • Easy storage and sharing of data for future analysis.

4.7 Conclusion

Thematic analysis, often referred to as Qualitative Content Analysis (QCA) in Europe, is one of the most widely used approaches for qualitative data. Developing codes and categories is a proven strategy for analysing qualitative data. The significance of the qualitative method is that it is relatively easy to learn, straightforward, authentic, and other researchers can understand it easily. Furthermore, qualitative data is more complex and diverse compared to quantitative data as the data may comprise different sources, such as interview transcripts, focus group discussions, field notes, and information available on websites in the form of text, audio, or videos (Kuckartz, 2019).

The objective of addressing the research questions is the overall purpose of the study. Therefore, selecting an appropriate methodology is crucial as it helps find the best possible answer to a research question. The nature of the research questions determines the methodology and selection of methods. Grounded theory studies can be used for research studies when (Volstedt and Rezat, 2019):

1. There is a lack of theoretical foundations or a gap in existing theories.
2. The relationships between the concepts have not been verified.

This research study selected grounded theory to understand the foundations of the core concepts of the study which are entrepreneurial pivoting, technology entrepreneurship, and the technology S-curve. Furthermore, grounded theory studies are utilised for understanding the relationship between the theories of entrepreneurial pivoting and technology entrepreneurship, and between the technology S-curve and entrepreneurial pivoting.

Any research study commences with performing a literature review. As part of the literature review, the study focused on exploring the concepts of entrepreneurship, technology entrepreneurship, the Lean Startup Approach, pivoting and the factors that cause pivoting, technology forecasting, the technology S-curve, and the role of leadership styles in entrepreneurship. The literature review enabled the study to develop focused research questions to understand the relationship between the abovementioned concepts.

Figure 18 illustrates the process of data collection pursued in the study. After completion of the literature review, qualitative data was collected in two modes, mainly primary and secondary data—the process of collecting secondary data involved studying information available in journal articles, conference papers and websites. Firstly, the study collected information on tech startups that have pivoting experiences in the past and the factors behind those pivots. The study collected pivoting information on eighty tech startups as part of the secondary data collection. The next step in the research study was to collect empirical data. Therefore, purposive sampling was adopted to approach high-tech entrepreneurs across the UK. Thirty tech entrepreneurs agreed to be part of the research study with whom primary interviews were conducted to understand a tech startup's journey through the lens of entrepreneurial pivoting. In addition to thirty interviews, longitudinal interviews were conducted with nine tech entrepreneurs to understand the relationship between the core concepts of entrepreneurial pivoting, technology entrepreneurship and the technology S-curve.

Qualitative data starts with collecting materials through various methods such as interviews, case studies, records, and documents (i.e., audio, video, and text files). Once the data is collected, qualitative analysis begins i.e., transcriptions. It is one of the most critical phases in qualitative analysis as it establishes the overall quality of the research. This process involves converting the data from audio and video format into text. Once data was converted into text, the initial coding process started to improve the understanding of the experience of tech entrepreneurs regarding pivoting. The initial coding enabled the study to classify participant experiences into categories and themes. The themes and their categories are considered cornerstones of developing theory (Corbin and Strauss, 1990). Figure 19 depicts the tools and techniques used in the study to code the qualitative data. Post manual analysis involved initial coding and the study used NVivo software to conduct the second cycle of coding i.e., axial coding.

Figure 18. Data collection process employed in the study.

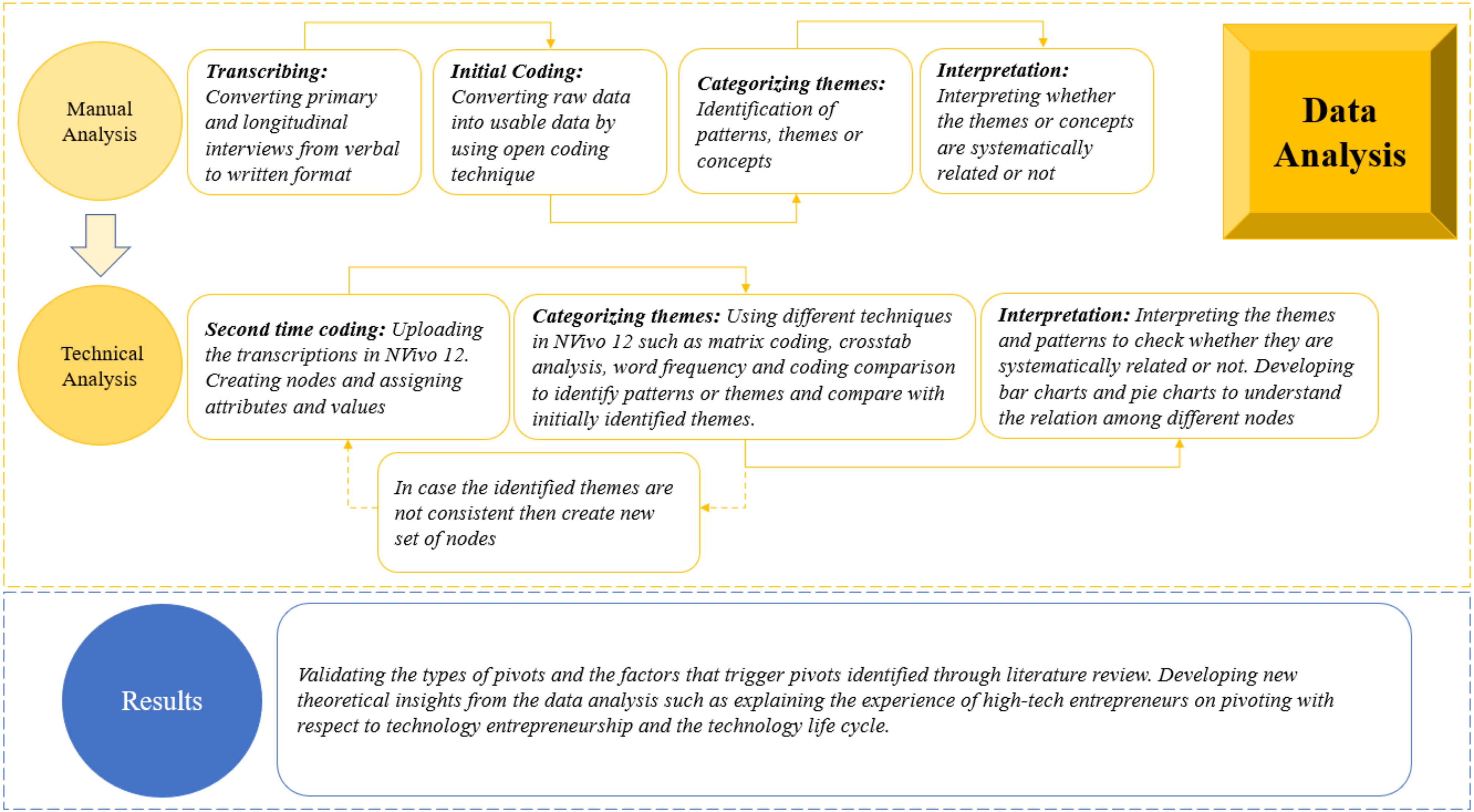

Figure 19. Data analysis process

The axial coding helped the study to investigate the relationship among the theories. In addition, it helped in broadening the categories and reorganising the data. The first and second coding cycles were the most time-consuming phases in qualitative analysis because the outcomes of research's validity and reliability are dependent on them (Srnka and Koeszegi, 2007). Finally, the study started interpreting the data and identifying new theoretical propositions concerning pivots and their factors. As a result, the research has validated the types of pivots and the factors that trigger pivots identified in the literature review. Furthermore, the data analysis allowed the study to investigate the relationship between the core theoretical concepts and identify new insights that are explained in the next chapter. The next chapter will explain the results obtained from the secondary data analysis and discuss the results, which will be followed by the chapters concerning primary data analysis and corresponding discussions.

Chapter 5: Results and discussion (secondary data)

5.1 Introduction

The objective of collecting and analysing secondary data was to enable an initial understanding of pivots and the factors that triggered those pivots before the collection of primary data. Therefore, the data of 80 startups/companies were studied to understand what type of pivot they pursued and the factor(s) behind those pivot(s).

5.2 Results of secondary data

As mentioned above, the research study gathered information on 80 tech startups/companies to comprehend the types of pivots and the factors behind those pivots collected from various sources such as Bajwa et al., (2017), Comberg et al. (2014), Terho et al. (2015) and Hirvikoski (2014) as well as various website sources. The study calculated calculated the number of times (and percentage) a pivot was pursued and the number of times a factor triggered pivoting across the 80 companies. Table 6 provides data on the frequency of pivots pursued by the tech startups, e.g., the social pivot was pursued the least (N=0; 0%) and the customer segment pivot was pursued the most (N=28; 15%).

Table 6. Frequency of pivots pursued by the tech startups.

Type of pivots	No. of times pursued	Percentage
Social pivot	0	0%
Market segment pivot	2	1%
Complete pivot	8	4%
Technology pivot	9	5%
Zoom-out pivot	10	5%
Platform pivot	11	6%
Zoom-in pivot	13	7%

Type of pivots	No. of times pursued	Percentage
Channel pivot	14	7%
Business architecture pivot	14	7%
Engine of growth pivot	17	9%
Side project pivot	17	9%
Value capture pivot	21	11%
Customer need pivot	23	12%
Customer segment pivot	28	15%
Grand Total	**187**	**100%**

The bar chart in Figure 20 represents the frequency of factors that caused the pivots. For example, the factor 'customer feedback' made twenty-seven tech startups/companies' pivot. Seven of these twenty-seven startups used a 'zoom-in pivot'; four pursued a 'customer segment pivot'; eight pursued a 'customer need pivot'; five pursued a 'complete pivot'; three pursued a 'platform pivot', 'channel pivot' or a 'market segment pivot'. The bar chart shows that the flawed business model was the most frequent factor (N=30; 16%), followed by customer feedback (27; 14%) and technology challenges (N=24; 13%). Whereas competition, wrong timing, and legal issues (N=4; 2%, N=3; 2%, and N=1; 1%, respectively) are the least frequent factors.

Similarly, Figure 21 represent the frequency of pivots. Customer segment pivot and customer need pivot are the most frequently pursued pivots by these eighty tech startups/companies. From the bar chart one can understand that market-level and strategy-level pivots are the most frequently adopted category of pivots. For instance, the customer segment pivot was the highest pursued pivot (N=28, 15%). Customer need pivot is the second most pursued pivot among the 80 startup companies (N=23, 12%) followed by value capture pivot (N=21, 11%) and side project pivot (N=17, 9%). The study could not identify a single tech startup that pursued social pivots to validate. Therefore, the most pursued pivots are the customer segment, customer need, and value capture pivots. Similarly, the flawed business model, customer feedback and technology challenges are the most frequent factors.

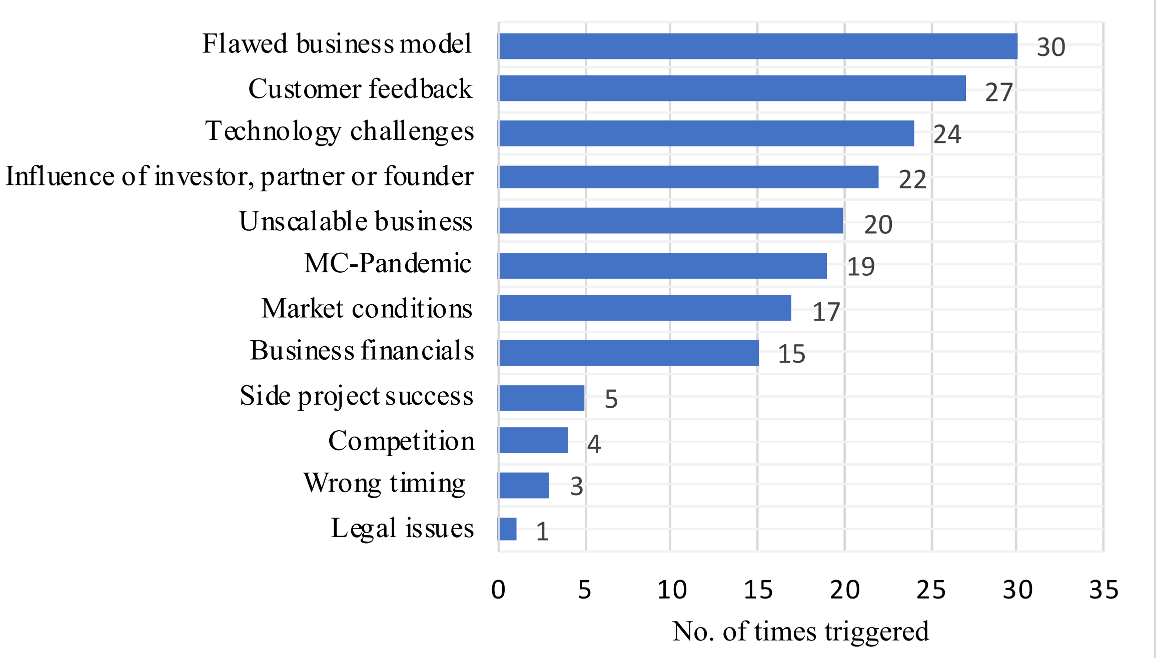

Figure 20. Frequency of factors that caused pivots.

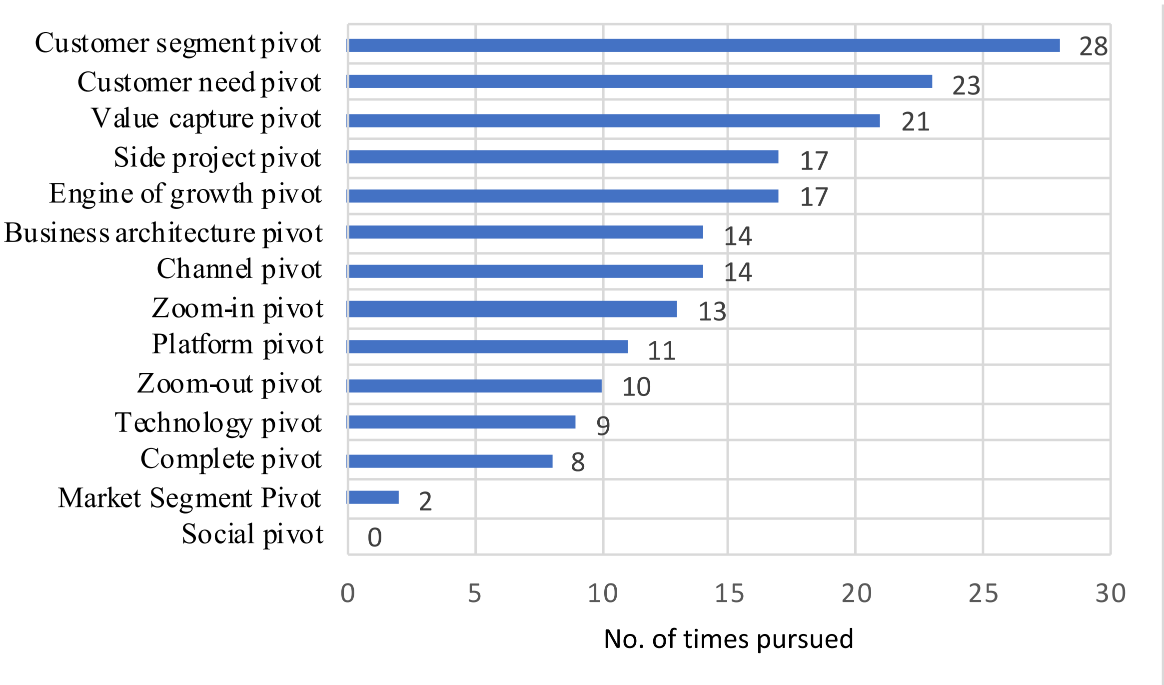

Figure 21. Frequency of pivots pursued by the tech startups.

Through the secondary data, the research study was concerned to determine the correlation between the factor and the types of pivots. Therefore, the secondary data was further analysed, and Figure 22 (bar graph) depicts the number of times a factor initiated a pivot. For example, the zoom-in pivot was pursued because of seven factors, namely: customer feedback, technology challenges, unscalable business, market conditions, wrong timing, flawed business model and business financials. Similarly, for the customer segment pivot which is the most frequently pursued pivot among the eighty tech startups/companies mainly due to ten factors, i.e., customer feedback, technology challenges, unscalable business, market conditions, competition, the influence of investor, promoter, or founder, flawed business model, business financials, side project success and market conditions (due to pandemic).

Another example is the customer need pivot, the second most frequently practised pivot among the eighty tech startups/companies. The factors associated with customer need pivot are customer feedback, unscalable business, competition, wrong timing, the influence of investor, promoter or founder, flawed business model and market conditions (due to pandemic). The study conducted correlation coefficient and cluster analysis to identify the correlation between factors and pivots. However, no correlation was identified between the factors and pivots adapted to address those factors.

5.3 Discussion

The intent behind studying the secondary data of the 80 companies reported in published sources was to provide a preliminary understanding of the concept of pivoting and the factors behind those pivots. In the results section, the study identified the most pursued pivots and the most triggering factors through the secondary data analysis. The factor vs pivot (Figure 22) identifies the factors that triggered a particular pivot.

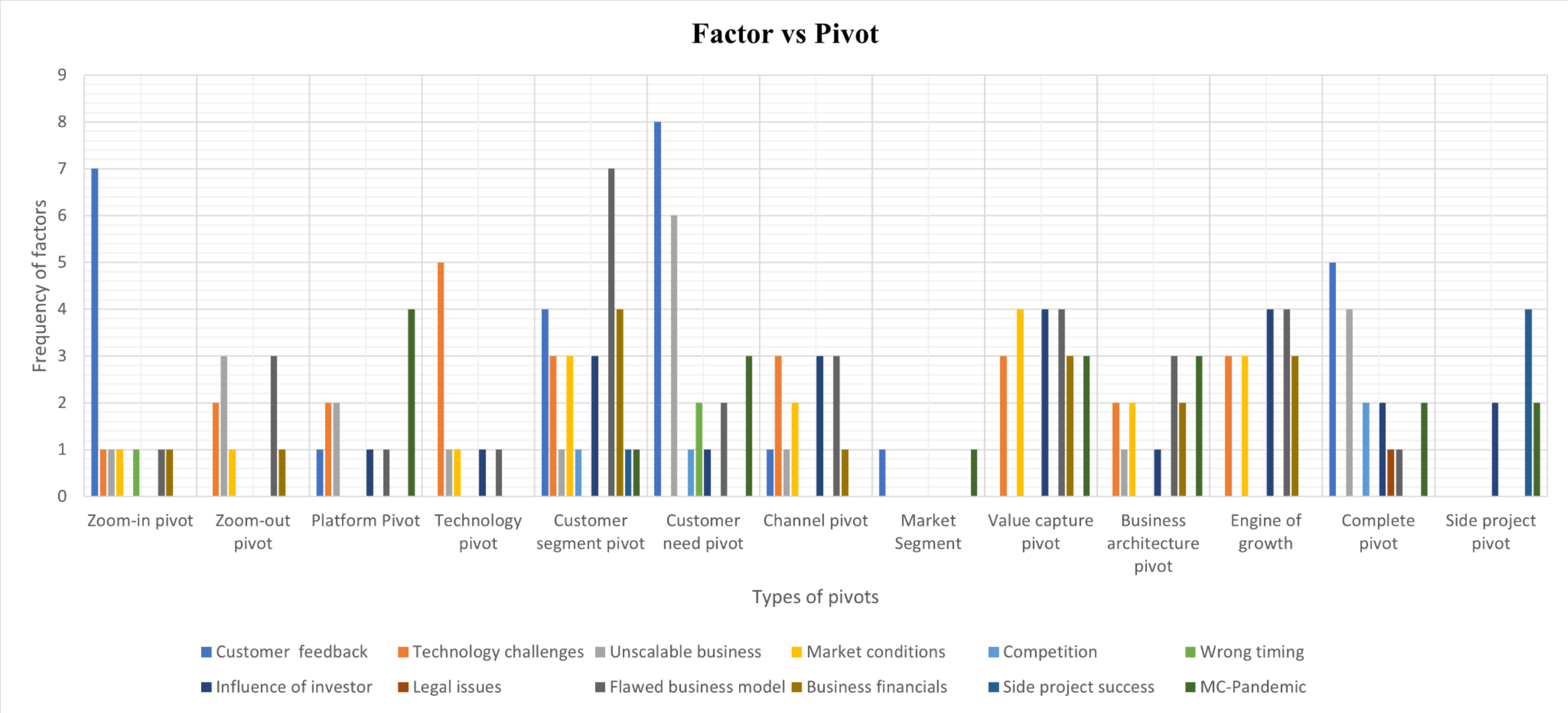

Figure 22. Factor vs pivots.

Upon examining the secondary data, the research study identified that among the 80 tech startups/companies, the product-level pivots (i.e., zoom-in, zoom-out, technology and platform pivot) were the least pursued pivots. Whereas the most pursued pivots were from the market-level pivots (i.e., customer segment, customer need, channel, and market segment pivot), followed by the strategy-level pivots (i.e., value capture, business architecture, the engine of growth, complete and side project pivot).

In terms of the most frequent factors that caused pivoting to take place, external factors such as customer feedback, technology challenges, competition, market conditions, and unscalable made the eighty startups/companies pivot more. Conversely, internal factors such as the influence of investors, partners or founder and flawed business models were the most triggering factors.

These findings have helped to improve the initial understanding of the concept of pivoting and the factors behind those pivots through providing preliminary evidence of the different types of pivots and factors. However, since the secondary data was collected during the recent global pandemic, the study collected the data of companies that pivoted from their original business models to survive COVID-19 situation. For those companies, the study has defined the factor for pivoting as Market Conditions (pandemic). The tech startups that pivoted due to market conditions (due to pandemic) mostly pursued the platform pivot, value capture pivot and business architecture pivot. The secondary data analysis indicated that these pivots were pursued either due to disruption in demand and supply or the short-term opportunity generated by COVID-19. A few startups pursued the platform pivot because they could not continue their original business due to COVID-19. However, they realised they did not need to find a new business idea or a business model, but the existing platforms could themselves be a service to cater to customers' needs. For example, a tech startup from the list of eighty companies used its website to order groceries and other necessary items, which was earlier used to book cabs and taxis. Similarly, tech startups changed how they used to charge for subscriptions and provided multiple schemes to gain more customers. This is an example of a value capture pivot where a tech startup changes its ways of capturing money.

Analysis of the secondary data has helped to provide an initial base for the research study. The next step in the study is to collect the primary data, perform qualitative data analysis, and evaluate to what extent the empirical results match the secondary data analysis. In the next chapter, the results of the initial thirty interviews will be provided and discussed to understand the concepts of pivots, factors that trigger pivots, technology entrepreneurship, technology S-curve as well as other aspects, such as the domino effect and the link to the company's value proposition.

5.4 Conclusion

From the secondary data analysis, the study observed that the most frequently pursued pivots are market-level category pivots, i.e., customer segment pivot (15%) and customer need pivot (12%); followed by strategy-level pivots i.e., value capture pivot (11%). In addition, the secondary data analysis has illustrated the factors and pivots pursued to address those factors. However, the study could not determine any correlation between the types of pivots and factors that initiated those pivots. Similarly, the study could not identify examples of the social pivot, which was identified by Hirvikoski (2014). Furthermore, the research study has looked into tech startups/companies that pivoted during COVID-19 and explained the possible motivation behind those pivots.

Apart from validating types of pivots and the factors which initiate them, the study is focused on understanding the concept of technology entrepreneurship, the lean startup approach, pivots, and the factors that trigger such pivots. Technology entrepreneurship is a critical field that can substantially enhance economic growth and create new technology-driven market opportunities (Eliakis et al., 2020). Therefore, how can a technology startup company survive in the long run? One way to address the question is by implementing the LSA since the LSA encourages startups to interact with customers and encourages them to test new fundamental hypotheses to improve their product/service based on the feedback (Felin et al., 2020). Hence, the study collected primary data and conducted qualitative data analysis to understand more about LSA, pivots, TE, technology S-curve, TRL, and leadership styles. In the next chapter, the research study will explain the results of the primary thirty interviews and discuss the factors that trigger a tech startup to change direction by pursuing different pivots.

Chapter 6: Results and discussion (Primary data: First thirty interviews – part a)

6.1 Introduction

Shepherd and Gruber (2020) identified that there is a gap between academic researchers and practitioners in entrepreneurship. The goal of this study is to build a bridge between these often-disparate communities. Therefore, the study focused on understanding the characteristics of entrepreneurial pivoting as well as the influence of technology maturity on pivoting and whether pivoting leads to a change of the main technology used by a tech startup. The qualitative analysis is based on interviewing thirty high-tech entrepreneurs to understand their pivoting experience and the influence of technology maturity on pivoting. Out of 30 participants, 26 (80%) were male, and 4 (20%) were female tech-entrepreneurs. In addition, most of the interviewees were designated as CEO (chief executive officer) in their respective tech startups (N=26, 86%). However, there were also two (7%) CTOs (chief technology officers) and two (7%) Non-Executive Directors (NEDs).

The overall experience of the 30 entrepreneurs is 288 years, with an average experience of 9.6 years each. The top two technology sectors with the highest percentage of tech entrepreneurs among the participants are internet technology (N=10, 33%) and software technology (N=9, 30%). Whereas four participants (N=4, 13%) are from the biotechnology, medical, instrumentation and medical pharmaceutical technology sector, and two participants (N=2, 7%) are from the communication technology sector. The rest of the participants (N=5, 17%) are from other electronics related technology sectors. Figure 23 illustrates the percentage of tech entrepreneurs from each technology sector.

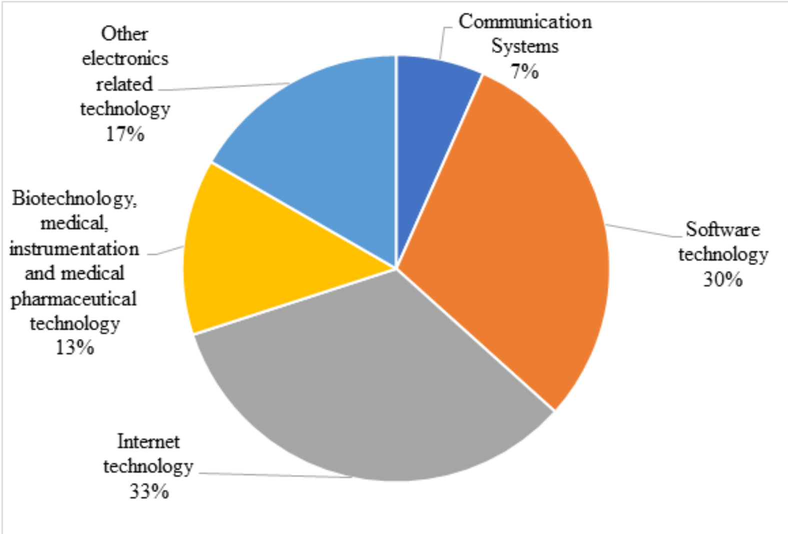

Figure 23. Percentage of tech entrepreneurs from each tech sector.

The results of the primary thirty interviews are presented in two parts (part a and part b). In this chapter i.e., part-a, the study discussed the different types of pivots classified under three categories and the factors that trigger those pivots. The following sections are on the types of entrepreneurial pivots and the factors that cause entrepreneurial pivots. This will explain how the study has validated the existing pivots and factors identified from the literature review and recognised new pivots and factors.

6.2 Types of entrepreneurial pivots

First and the foremost, through the qualitative analysis, the study validated all fourteen types of pivots that were identified in the literature review by Ries (2011), Bajwa *et al.* (2017) and Hirvikoski (2014). Table 7 provides details on the pivots pursued by the tech startups and the factors associated with the corresponding pivots.

Table 7. Pivots and corresponding factors identified in the interviews.

Participant ID	Type of pivot	Factors
Participant-1	1.Complete pivot (pursued 3 times)	1. Competition and market conditions

Participant-2	2a. Market segment pivot 2b. Customer segment pivot 2c. Customer need pivot 2d. Side project pivot	2a. Influence of investor, partner or founder and legal issues 2b. Customer feedback, technology challenges and unscalable business 2c. Influence of investor, partner or founder, technology challenges and market conditions 2d. Side project success and customer feedback
Participant-3	3a. Zoom-in pivot 3b. Zoom-out pivot 3c. Customer segment pivot 3d. Customer need pivot 3e. Channel pivot 3f. Engine of growth pivot 3g. Side project pivot	3a. Competition 3b. Competition 3c. Unscalable business 3d. Customer feedback 3e. Unscalable business 3f. Flawed business model 3g. Influence of investor, partner or founder, market conditions and side project success
Participant-4	4a. Market segment pivot 4b. Customer segment pivot 4c. Customer need pivot 4d. Value capture pivot 4e. Side project pivot 4f. Channel pivot	4a. Wrong timing 4b. Competition 4c. Customer feedback 4d. Competition 4e. Side project success and technology challenges 4f. Side project success
Participant-5	5a. Zoom-in pivot 5b. Technology pivot 5c. Customer segment pivot 5d. Business architecture pivot	5a. Customer feedback 5b. Technology challenges 5c. Competition 5d. Competition
Participant-6	Did not pursue any pivot	N.A.
Participant-7	7a. Customer need pivot 7b. Customer segment pivot 7c. Technology pivot	7a. Customer feedback 7b. Flawed business model, Wrong timing, and market conditions 7c. Unscalable business, wrong timing, technology challenges and market conditions
Participant-8	8a. Customer segment pivot 8b. Zoom-out pivot 8c. Platform pivot 8d. Channel pivot	8a. Competition, customer feedback and market conditions 8b. Competition and customer feedback 8c. Customer feedback 8d. Customer feedback
Participant-9	9a. Side project pivot 9b. Customer segment pivot	9a. Side project success 9b. Market conditions

Participant-10	10a. Customer segment pivot 10b. Market segment pivot	10a. Customer feedback, influence of investor, partner or founder and technology challenges 10b. Influence of investor, partner, or founder
Participant-11	11a. Technology pivot 11b. Platform pivot 11c. Customer segment pivot 11d. Customer need pivot 11e. Channel pivot 11f. Market segment pivot 11g. Engine of growth pivot 11h. Side project pivot	11a. Technology challenges and competition 11b. Customer feedback, influence of investor, partner or founder, market condition and competition 11c. Customer feedback, competition, Wrong timing and influence of investor, partner, or founder 11d. Customer feedback, competition, wrong timing, influence of investor, partner or founder and market conditions 11e. Influence of investor, partner, or founder, unscalable business and competition 11f. Market conditions, competition, unscalable business and technology challenges 11g. Market conditions, influence of investor, partner or founder, technology challenges and unscalable business 11h. Customer feedback, technology challenges, competition, unscalable business, wrong timing, market conditions and influence of investor, partner, or founder
Participant-12	12a. Zoom-out pivot 12b. Customer segment pivot 12c. Channel pivot 12d. Business architecture pivot	12a. Customer feedback and flawed business model 12b. Flawed business model 12c. Customer feedback and unscalable business 12d. Business financials
Participant-13	13a. Zoom-in pivot 13b. Customer segment pivot 13c. Customer need pivot 13d. Channel pivot 13e. Market segment pivot 13f. Value capture pivot 13g. Business ecosystem pivot 13h. Brand pivot	13a. Customer feedback and competition 13b. Competition and market conditions 13c. Market conditions 13d. Market conditions 13e. Market conditions 13f. Market conditions and competition 13g. Market conditions 13h. Customer feedback

Participant-14	14a. Side project pivot 14b. Customer segment pivot 14c. Business architecture pivot 14d. Social pivot 14e. Technology pivot	14a. Side project success 14b. Customer feedback 14c. Customer feedback 14d. Legal issues 14e. Technology challenges and influence of investor, partner, or founder
Participant-15	15a. Customer segment pivot 15b. Channel pivot 15c. Value capture pivot	15a. Competition, market conditions and geopolitical issues 15b. Competition, market conditions and geopolitical issues 15c. Strategic longevity and side project success
Participant-16	16a. Zoom-in pivot 16b. Technology pivot 16c. Platform pivot 16d. Customer segment pivot 16e. Customer need pivot	16a. Legal issues 16b. Technology challenges 16c. Legal issues 16d. Legal issues 16e. Customer feedback
Participant-17	17a. Side project pivot 17b. Technology pivot 17c. Zoom-out pivot 17d. Customer need pivot	17a. Side project success and customer feedback 17b. Technology challenges and side project success 17c. Side project success and customer feedback 17d. Customer feedback and competition
Participant-18	Tech Startup-1: Customer need pivot Tech Startup-2: Customer segment pivot Tech Startup-3: Platform pivot	Tech Startup-1: Customer feedback Tech Startup-2: Influence of investor, partner, or founder Tech Startup-3: Flawed business model
Participant-19	19a. Zoom-in pivot 19b. Zoom-out pivot 19c. Platform pivot 19d. Customer segment pivot 19e. Channel pivot 19f. Market segment pivot 19g. Value capture pivot 19h. Engine of growth pivot 19i. Business architecture pivot 19j. Complete pivot	19a. Customer feedback, competition, and market conditions 19b. Customer feedback, competition, and market conditions 19c. Customer feedback, competition, and market conditions 19d. Customer feedback and wrong timing 19e. Customer feedback and competition 19f. Competition 19g. Competition 19h. Customer feedback 19i. Customer feedback

	19k. Side project pivot 19l. Social pivot	19j. Customer feedback, influence of investor, partner, or founder, legal issues, side project success and business financials 19k. Customer feedback, wrong timing, and market conditions 19l. Influence of investor, partner, or founder, legal issues, side project success and business financials
Participant-20	20a. Zoom-in pivot 20b. Zoom-out pivot 20c. Platform pivot 20d. Customer segment pivot 20e. Customer need pivot 20f. Side project pivot	20a. Technology challenges 20b. Competition 20c. Flawed business model 20d. Side project success 20e. Customer feedback and flawed business model 20f. Competition
Participant-21	21a. Channel pivot 21b. Side project pivot	21a. Wrong timing 21b. Wrong timing
Participant-22	22a. Customer need pivot 22b. Value capture pivot	22a. Customer feedback and wrong timing 22b. Customer feedback and wrong timing
Participant-23	23. Technology pivot	23. Wrong timing and influence of investor, partner, or founder
Participant-24	24a. Zoom-out pivot 24b. Technology pivot 24c. Platform pivot 24d. Channel pivot 24e. Market segment pivot 24f. Value capture pivot 24g. Engine of growth pivot 24h. Business architecture pivot 24i. Side project pivot	24a. Customer feedback 24b. Strategic longevity 24c. Strategic longevity and unscalable business 24d. Influence of investor, partner, or founder 24e. Market conditions 24f. Influence of investor, partner, or founder 24g. Influence of investor, partner, or founder 24h. Customer feedback 24i. Influence of investor, partner or founder, side project success and strategic longevity
Participant-25	25a. Platform pivot 25b. Channel pivot 25c. Value capture pivot 25d. Engine of growth pivot 25e. Side project pivot 25f. Social pivot 25g. Technology pivot	25a. Technology challenges 25b. Unscalable business and flawed business model 25c. Flawed business model 25d. Business financials 25e. Business financials 25f. Flawed business model

		25g. Technology challenges and unscalable business
Participant-26	26a. Business architecture pivot 26b. Customer segment pivot	26a. Technology challenges and business financials 26b. Business architecture pivot led to pursue this pivot
Participant-27	27a. Customer segment pivot 27b. Channel pivot 27c. Engine of growth 27d. Business architecture pivot	27a. Market conditions and influence of investor, partner, or founder 27b. Business financials and customer feedback 27c. Competition, business financials and customer feedback 27d. Competition and business financials
Participant-28	Tech Startup-1: Customer segment pivot Tech Startup-2: Side project pivot Company-A: Business architecture pivot	Tech Startup-1: Influence of investor, partner, or founder Tech Startup-2: Technology challenges, side project success and business financials Company-A: Influence of investor, partner, or founder
Participant-29	29a. Zoom-out pivot 29b. Channel pivot	29a. Strategic longevity 29b. Competition
Participant-30	30. Customer need pivot (pursued this pivot twice)	30. Technology challenges, Unscalable business, wrong timing, market conditions, customer feedback and influence of investor, partner, or founder

Participants 19, 24, 11 and 13 are the four high-tech entrepreneurs with the most pivoting experience out of the thirty interviewees. For instance, participant 19 pursued twelve different pivots, whereas participant 24 pursued nine pivots. Whereas participants 11 and 13 pursued eight pivots each. Many participants were involved in multiple tech startups, but they explained in their interviews the pivoting experience with respect to one of their companies. However, participants 18 and 28 explained their pivoting experience across all the companies in which they were involved. Participant 18 was involved in three tech startups, and the data is therefore mentioned as Tech startup 1, 2 and 3. Similarly, participant 28 was also associated with multiple tech companies. This participant has thirty plus years of experience in the tech industry in which they worked with two tech startups and one large corporate from the tech industry. Therefore, their data is mentioned as Tech startup 1 and 2, and Company A.

The project used matrix coding to analyse the dataset with respect to the attributes defined while coding the data. Matrix coding was conducted to determine the technology sector with the most company pivots and the type of pivot(s) pursued. The tech startups in the internet technology sector are the ones that pivoted the most (N=41). The following two technology sectors in terms of pivoting frequency are software technology (N=33) and communication systems (N=21). The study did not have a single tech entrepreneur from the semiconductor technology sector. The highest pursued pivots among all the tech sectors are customer segment pivot (N=20), customer need pivot (N=14), channel pivot (N=13) and side project pivot (N=11).

6.2.1 Pivoting experience of the tech entrepreneurs

During the interviews, participants were asked to share their experience on pivoting. The following are selected participant quotations on pivoting: Participant 1 said, "*Pivoting is a funnelling effect, and it is a process which is very iterative* [*sic*]." Likewise, participant 15 explained, *"At the end of the day, growth is what startup needs. Pivoting is an ongoing process* [*sic*].*"* Similarly, participant 25 said, *"Pivoting is a function of a turnaround activity and putting strategies in places while rethinking the direction of travel* [*sic*].*"*

Participant 13 mentioned, *"There's two things that happen the first thing that happens, is that your hypothesis doesn't play out that you're working on and it's not successful. When you find that it's not successful you pivot to try and find a hypothesis that is successful. The second catalyst for pivoting is when the market changes* [*sic*].*"*

Similarly, Participant 24 said, *"Yeah, every company pivots. I do not know of any company that's ever really had the business plan on day one and implemented business plan in day two it's just not true. Every company I know of every experience I have had is that it is a constant journey of evolution and adaption* [*sic*].*"*

Participant 8 explained, *"How I look at the pivots help you go in the right direction if they are* *right for you. Sometimes it can backfire. But when we are talking about the ideal condition and what is the reason of doing a pivot is to go into the right direction* [*sic*]*."*

Participant 13, who has more than thirty years of experience in the tech industry, mentioned two new types of pivots that their startups pursued. He identified them as 'business ecosystem pivot' and 'brand pivot'. The following are the quotes of the participant explaining about the above two pivots.

Participant 13 mentioned about the business ecosystem and partnerships. The tech entrepreneur said that *"I think it is around ecosystems and partnerships. So, I would distinguish ecosystems and partnerships from channels. So, often people pivot in the way that they are going to market with other businesses or on their own. Sometimes you can partner with the business, and it is not channel. It is a new architecture you are putting in place. It is kind of almost comes out of business architecture, channel, and partnership. I am not seeing partnership in here anywhere. I am not seeing ecosystem* [*sic*]*."*

The interviewee also explained about brand pivot. *"We currently have multiple brands and what we are going to do is collapse them into one brand and one domain and do what I would call a brand pivot and then actually we're going to rebrand the business and relaunch it* [*sic*]*."*

A business ecosystem pivot is defined as a strategic alliance or partnership that is pursued by two startups to gain more customers and enter new market segments. By Contrast, when startups offer multiple products under different brands, they may lose a degree of customer engagement. Therefore, startups can rebrand their products into a single brand and domain, called a brand pivot. This helps in creating a clear image of the product for customers. These two pivots can be categorised into strategy level pivots as they represent strategic decisions taken by a company to expand the business. The study validated all 14 types of pivots from the literature and identified these 2 new pivots, thereby giving a new total of 16 pivots.

Table 9 illustrates the types of pivots the interviewees pursued. In addition, the data analysis identified how many times the participants pursued a particular pivot. Figure 24 illustrates the frequency of each pivot pursued by the participants. For example, the frequency of the customer segment pivot was 36 times. Furthermore, it was the highest pursued pivot identified by the participants.

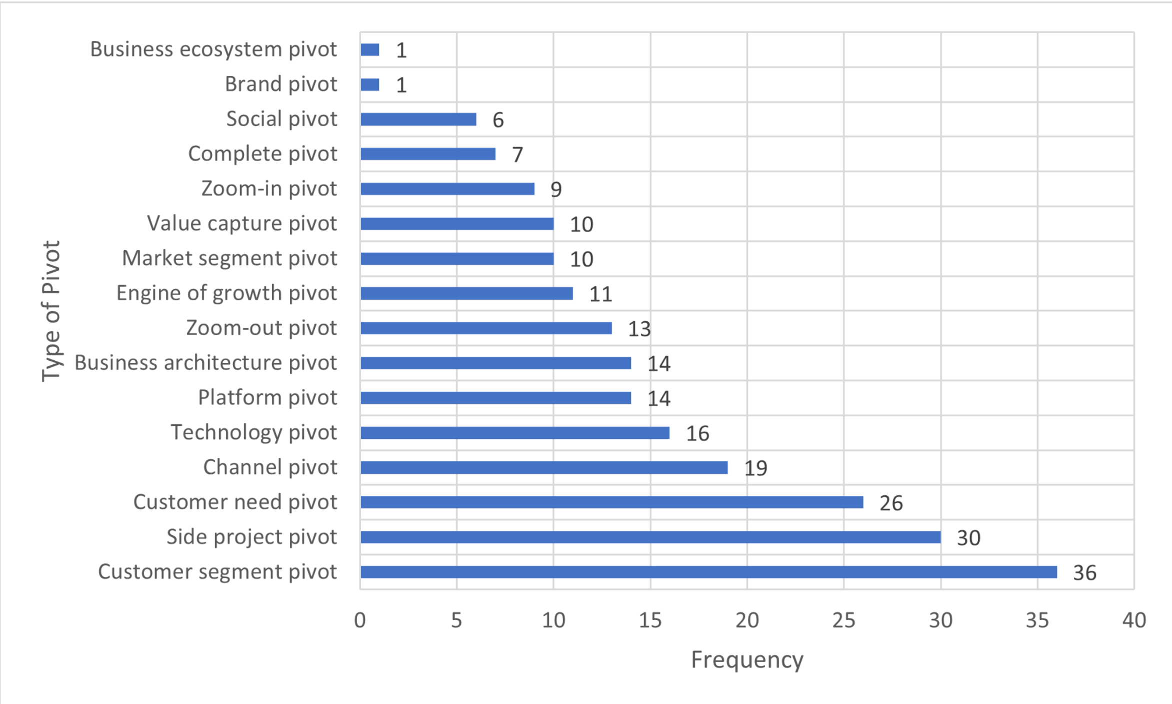

Figure 24. Number of times each pivot was identified by participants.

Similarly, the second most pursued pivot mentioned by the interviewees was the side project pivot, which was identified 30 times. By Contrast, customer need pivot was the third most frequently pursued pivot by the participants. Figure 24 shows the types of pivots and their frequency (i.e., the number of times the interviewee mentioned that a company they were associated with had pivoted). The bar chart depicts the frequency of pivots in ascending order. Of the fourteen pivots identified from the literature review, the social pivot was the least pursued by the participants. The two new pivots i.e., brand pivot and business ecosystem pivot, identified through qualitative data analysis, were the least pursued (each had a single pivot), and they were mentioned by Participant 13.

As explained in the literature review, pivots can be organised into four categories i.e., product level, market level, strategy level and team level pivots. Upon analysing the data using qualitative techniques, the research study assembled the pivots pursued by the participants in the categories mentioned above. For example, Table 8 details the four pivots i.e., platform pivot, technology pivot, zoom-in pivot, and zoom-out pivot, under the product level pivot category. Furthermore, it explains which participant has pursued a particular pivot under the product level pivot category.

Table 8. Product-level pivots.

No.	Participant-ID	Pivot
1	Participant 3a	Zoom-in pivot
2	Participant 3b	Zoom-out pivot
3	Participant 5a	Zoom-in pivot
4	Participant 5b	Technology pivot
5	Participant 7c	Technology pivot
6	Participant 8b	Zoom-out pivot
7	Participant 8c	Platform pivot
8	Participant 11a	Technology pivot
9	Participant 11b	Platform pivot
10	Participant 12a	Zoom-out pivot
11	Participant 13a	Zoom-in pivot
12	Participant 14e	Technology pivot
13	Participant 16a	Zoom-in pivot
14	Participant 16b	Technology pivot
15	Participant 16c	Platform pivot
16	Participant 17b	Technology pivot
17	Participant 17c	Zoom-out pivot
18	Participant 18 TS-3	Platform pivot
19	Participant 19a	Zoom-in pivot
20	Participant 19b	Zoom-out pivot
21	Participant 19c	Platform pivot
22	Participant 20a	Zoom-in pivot
23	Participant 20b	Zoom-out pivot
24	Participant 20c	Platform pivot
25	Participant 23	Technology pivot
26	Participant 24a	Zoom-out pivot
27	Participant 24b	Technology pivot
28	Participant 24c	Platform pivot

29	Participant 25a	Platform pivot
30	Participant 25g	Technology pivot
31	Participant 29a	Zoom-out pivot

The alphabet letter represents the sequence of that pivot in the series of pivots pursued by respective participants. So, for instance, Participant 3a means the third participant in the interview and 'a' represents the first pivot they pursued. Similarly, Participant 7c means the seventh participant in the interview and 'c' denotes that their startup's third pivot is the technology pivot.

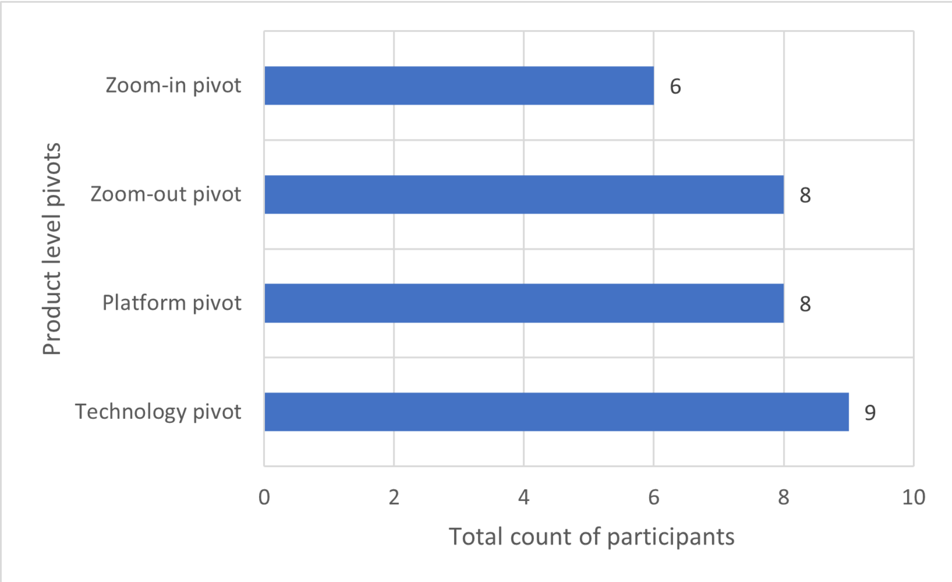

Figure 25. Frequency of product level pivots pursued by participants.

Figure 25 is a bar chart illustrating how many participants have pursued product-level pivots. Technology pivot (N=9, 29%) is the most pursued pivot within this category. It was followed by platform and zoom-out pivot (i.e., N= 8, 26%). Finally, the zoom-in pivot (N=6, 19%) was the least pursued among the four pivots.

The next group of pivots i.e., customer segment, customer need, channel, and market segment pivots, are categorised under market level pivots—Table 9 shows which participant has pursued a particular pivot under the market level pivot category. As mentioned above, the alphabet represents the sequence of that pivot in the series of pivots pursued by the respective participants.

Table 9. Market-level pivots.

No.	Participant-ID	Pivot
1	Participant 2a	Market segment pivot
2	Participant 2b	Customer segment pivot
3	Participant 2c	Customer need pivot
4	Participant 3c	Customer segment pivot
5	Participant 3d	Customer need pivot
6	Participant 3e	Channel pivot
7	Participant 4a	Market segment pivot
8	Participant 4b	Customer segment pivot
9	Participant 4c	Customer need pivot
10	Participant 4f	Channel pivot
11	Participant 5c	Customer segment pivot
12	Participant 7a	Customer need pivot
13	Participant 7b	Customer segment pivot
14	Participant 8a	Customer segment pivot
15	Participant 8d	Channel pivot
16	Participant 9b	Customer segment pivot
17	Participant 10a	Customer segment pivot
18	Participant 10b	Market segment pivot
19	Participant 11c	Customer segment pivot
20	Participant 11d	Customer need pivot
21	Participant 11e	Channel pivot
22	Participant 11f	Market segment pivot
23	Participant 12b	Customer segment pivot
24	Participant 12c	Channel pivot
25	Participant 13b	Customer segment pivot
26	Participant 13c	Customer need pivot
27	Participant 13d	Channel pivot
28	Participant 13e	Market segment pivot
29	Participant 14b	Customer segment pivot
30	Participant 15a	Customer segment pivot
31	Participant 15b	Channel pivot
32	Participant 16d	Customer segment pivot
33	Participant 16e	Customer need pivot
34	Participant 17d	Customer need pivot
35	Participant 18 TS-1	Customer need pivot
36	Participant 18 TS-2	Customer segment pivot

37	Participant 19d	Customer segment pivot
38	Participant 19e	Channel pivot
39	Participant 19f	Market segment pivot
40	Participant 20d	Customer segment pivot
41	Participant 20e	Customer need pivot
42	Participant 21a	Channel pivot
43	Participant 22a	Customer need pivot
44	Participant 24d	Channel pivot
45	Participant 24e	Market segment pivot
46	Participant 25b	Channel pivot
47	Participant 26b	Customer segment pivot
48	Participant 27a	Customer segment pivot
49	Participant 27b	Channel pivot
50	Participant 28 TS-1	Customer segment pivot
51	Participant 29b	Channel pivot
52	Participant 30	Customer need pivot

Figure 26 depicts how many participants have pursued market level pivots. The customer segment pivot (N=20, 38%) is the most pursued pivot within this category. It was followed by channel and customer need pivot (i.e., N=13, 25% and N=12, 23%, respectively). Whereas the market segment pivot (N=7, 13%) was the least pursued among the four pivots.

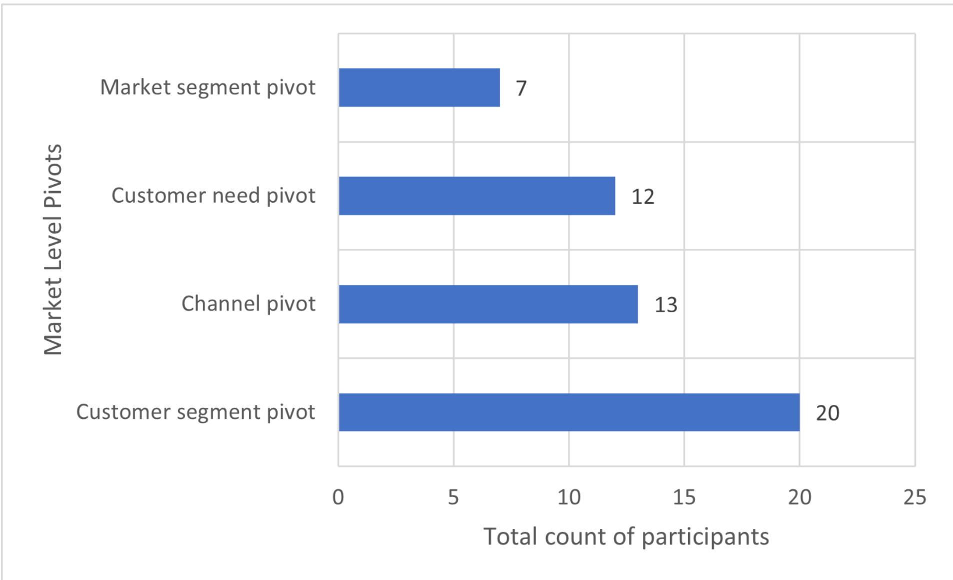

Figure 26. Frequency of market-level pivots pursued by participants.

The third group of pivots is called strategy level pivots, under which the following pivots are categorised; brand pivot, business architecture pivot, business ecosystem pivot, complete pivot, the engine of growth pivot, side project pivot and side project pivot. Table 10 illustrates how many participants have pursued strategy level pivots.

Table 10. Strategy-level pivots.

No.	Participant-ID	Pivot
1	Participant 1	Complete pivot
2	Participant 2d	Side project pivot
3	Participant 3f	Engine of growth pivot
4	Participant 3g	Side project pivot
5	Participant 4d	Value capture pivot
6	Participant 4e	Side project pivot
7	Participant 5d	Business architecture pivot
8	Participant 9a	Side project pivot
9	Participant 11g	Engine of growth pivot
10	Participant 11h	Side project pivot
11	Participant 12d	Business architecture pivot
12	Participant 13f	Value capture pivot
13	Participant 13g	Business ecosystem pivot
14	Participant 13h	Brand pivot
15	Participant 14a	Side project pivot
16	Participant 14c	Business architecture pivot
17	Participant 15c	Value capture pivot
18	Participant 17a	Side project pivot
19	Participant 19g	Value capture pivot
20	Participant 19h	Engine of growth pivot
21	Participant 19i	Business architecture pivot
22	Participant 19j	Complete pivot
23	Participant 19k	Side project pivot
24	Participant 20f	Side project pivot
25	Participant 21b	Side project pivot
26	Participant 22b	Value capture pivot
27	Participant 24f	Value capture pivot
28	Participant 24g	Engine of growth pivot
29	Participant 24h	Business architecture pivot
30	Participant 24i	Side project pivot
31	Participant 25c	Value capture pivot
32	Participant 25d	Engine of growth pivot
33	Participant 25e	Side project pivot
34	Participant 26a	Business architecture pivot
35	Participant 27c	Engine of growth pivot
36	Participant 27d	Business architecture pivot

37	Participant 28 TS-2	Side project pivot
38	Participant 28 C-A	Business architecture pivot

Figure 27 is a bar chart, which shows how many participants pursued strategy level pivots. The side project pivot (N=13, 34%) is the most pursued pivot within this category. It was followed by business architecture and value capture pivot (i.e., N=8, 21% and N=7, 18%, respectively). By Contrast, the brand pivot and business ecosystem pivot were mentioned only once.

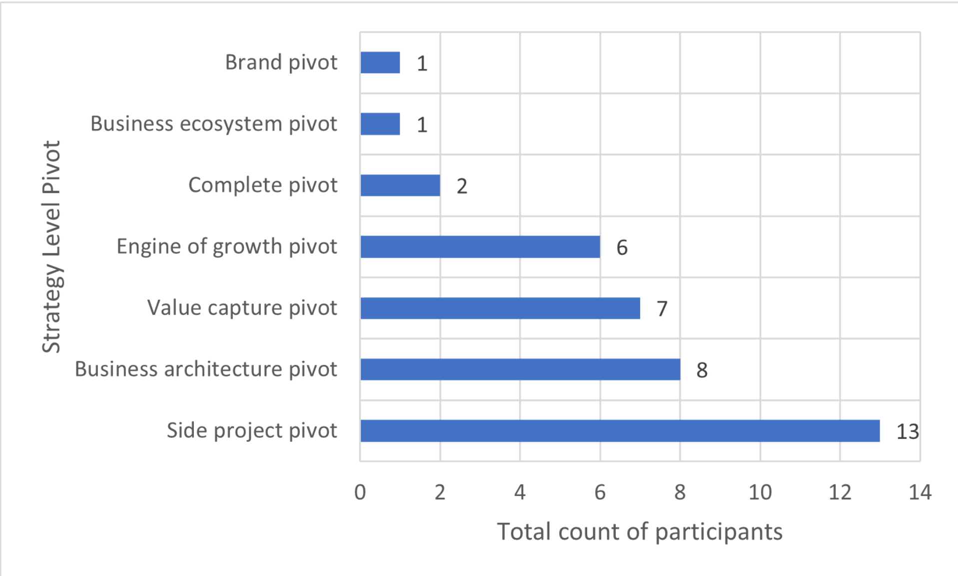

Figure 27. Frequency of strategy level pivots pursued by participants.

6.3 Factors that cause entrepreneurial pivots

The qualitative data analysis validated the eleven factors that cause pivots that were mentioned by Bajwa *et al.* (2017) and identified three new factors that trigger a tech startup to pivot. While discussing factors that trigger pivots, high-tech entrepreneurs mentioned terms such as ‘demand and supply’, ‘strategic longevity’, ‘substituted by a new entrant’, ‘for business expansion’, ‘adding value’, ‘geopolitical issues’ and ‘market opportunity’ as further reasons behind their tech startup’s pivoting. Upon further discussion, the study identified that some of these terms can be associated with existing factors. For example, earlier ‘market conditions’ was defined as a narrow market that may become saturated quickly. However, we have redefined ‘market conditions’ as a combination of the change in demand and supply with a niche market where a startup cannot sustain or thrive in the future. Similarly, ‘strategic longevity’ and ‘market opportunity’ can be grouped together. Therefore, the new definition of ‘strategic longevity’ is the advantage a startup acquires after broadening its solution in its operating sector. This also helps to eliminate competition and creates a deeper relationship with customers by providing additional value. ‘Substituted by a new entrant’ and ‘geopolitical issues’ are factors that are faced by almost every startup that conducts its business globally. Hence the three new factors are ‘geopolitical issues’, ‘substituted by a new entrant’ and ‘strategic longevity’. The first two new factors can be classified under external factors, whereas the third factor can be classified as an internal factor.

The following are selected participant quotations on the factors that cause entrepreneurial pivots. Participant 3 explained, *“Yeah, customer feedback definitely. We worked hard to make sure we had customer feedback all the time and all of our projects. We had that you had to talk to us a lot and that’s what drove it in a very Eric Ries kind of way* [*sic*]*.”*

Similarly, participant 28: *“In the case of Tech startup 1 which we touched on which was a side project pivot. I think that was a combination of technology challenges and side project success* [*sic*]*.”* In addition, participant 28: *“In the case of Company A, which re-engineered its business a business architecture pivot again, that was the influence of an investor, promoter or founder* [*sic*]*.”*

Participant 10 mentioned, *“Customer feedback and technology challenges, for these two factors the tech startup has adopted customer segment pivot* [*sic*]*.”* Likewise Participant 14 said, *“It was a social pivot because of legal issues* [*sic*]*.”* Conversely, participant 15 explained that *“Geopolitical issues are the reasons the startup pivoted* [*sic*]*.”*

Participant 16 said, *“The first pivot side project pivot, the factors were side project success and negative customer feedback* [*sic*]*.”*

The empirical analysis has identified the factors and their frequency. For example, the factor 'customer feedback' occurred 43 times and it was the most frequent factor that made a startup pursue a pivot. Similarly, the second most frequent factor identified by the interviewees was 'competition', which was identified 32 times. Whereas 'market conditions' was the third most frequent factor mentioned by the participants. Figure 28 shows the various factors that caused a pivot(s) and their frequency (i.e., the number of times the interviewee quoted the factor). The bar chart depicts the frequency of factors in ascending order. Of the eleven factors identified from the literature review, 'legal issues' was the least pursued by the participants. The two new factors i.e., 'strategic longevity' and 'geopolitical issues', were identified through qualitative data analysis.

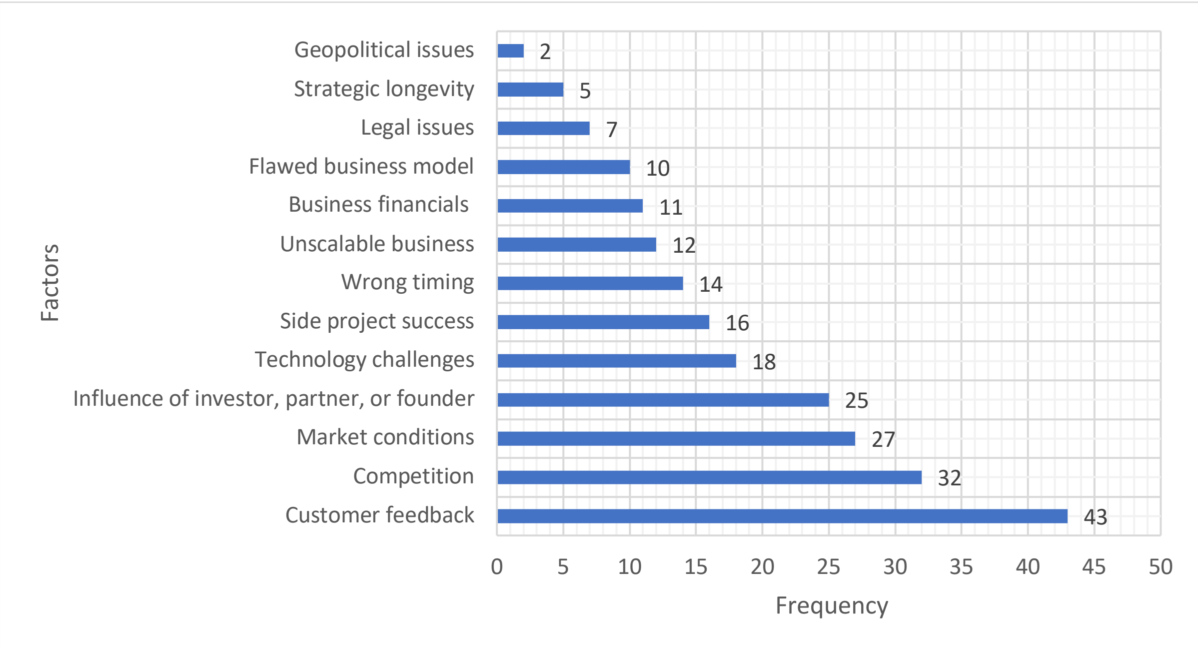

Figure 28. Factors that cause pivoting and their frequency.

6.3.1 Correlation between factors and pivots

As explained in the results and discussion chapter on secondary data, the research study investigated whether it is possible to identify any correlation between the factors and the pivots pursued due to those factors. Although no correlation between factors and pivots was found in the secondary data, the study investigated primary data to determine whether there was any correlation. In order to identify the correlation between factors and pivots, using qualitative techniques, the research study analysed transcriptions and converted them into quantitative data. The purpose behind converting qualitative data into quantitative data was to understand the frequency of pivot categories (i.e., product-level pivots, market-level pivots, strategy-level pivots, and team-level pivots) against each factor and see if any evidence of correlation is determined. In this section, the study will present the results collected through thirty primary interviews on pivot categories pursued against each factor.

For example, Table 11 details the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 1, i.e., customer feedback. Figure 29 depicts that market level pivots (N=19 times) were the most pursued pivots followed by strategy level pivots (N=13 times) by the tech entrepreneurs to address customer feedback factor.

Table 11. Frequency of pivot categories to address customer feedback (F-1).

Pivot Category	**Customer feedback**
Product level pivots	11
Market level pivots	19
Strategy level pivots	13
Team level pivots	0

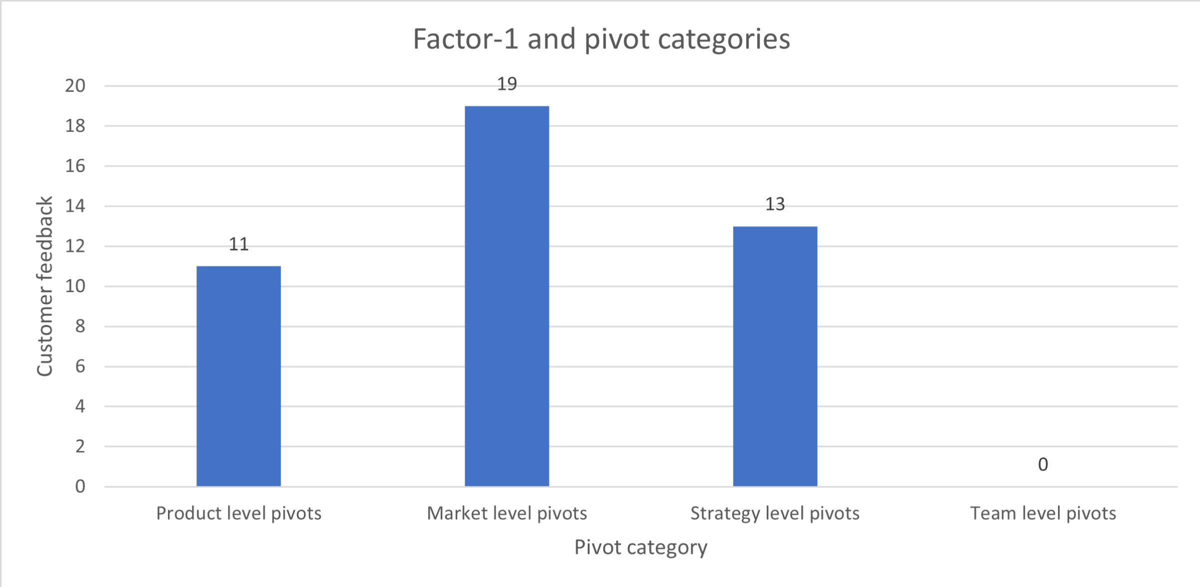

Figure 29. Frequency of pivot categories pursued by participants to address customer feedback.

Table 12 detailed the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 2, i.e., technology challenges. Figure 30 depicts that product level pivots (N=8 times) were the most pursued pivots followed by strategy and market level pivots (N=5 times) by the tech entrepreneurs to address the technology challenge factor.

Table 12. Frequency of pivot categories to address technology challenges (F-2).

Pivot Category	Technology challenges
Product level pivots	8
Market level pivots	5
Strategy level pivots	5
Team level pivots	0

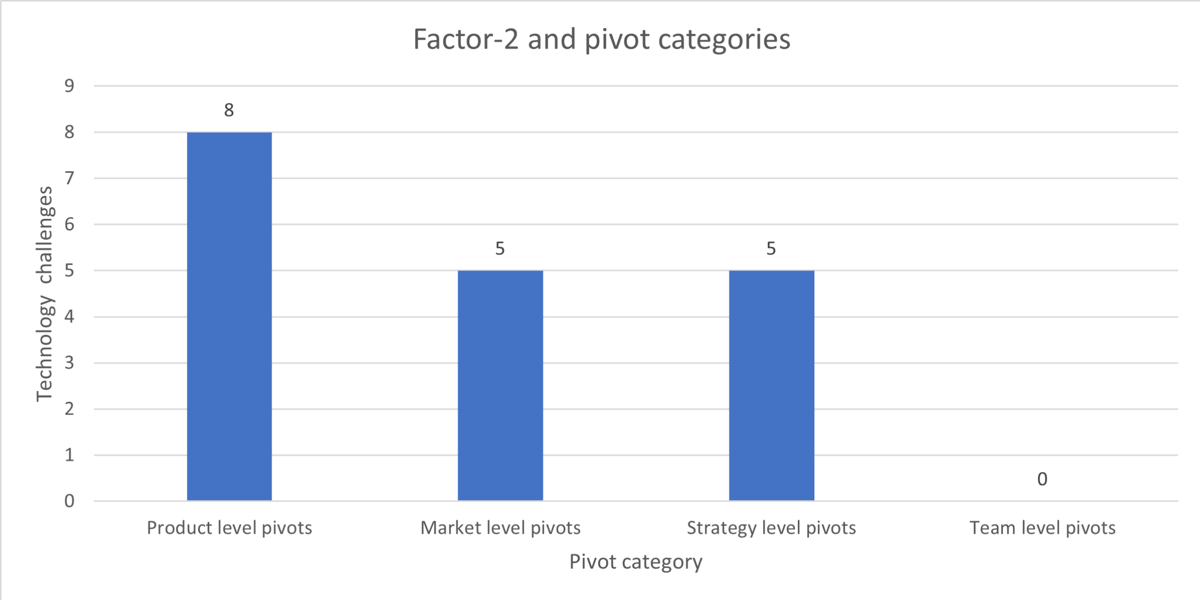

Figure 30. Frequency of pivot categories pursued by participants to address technology challenges.

Table 13 detailed the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 3, i.e., competition. Figure 31 depicts that market level pivots (N=14 times) were the most pursued pivots followed by product level pivots (N=10 times) by the tech entrepreneurs to address the factor called competition.

Table 13. Frequency of pivot categories to address competition (F-3).

Pivot Category	**Competition**
Product level pivots	10
Market level pivots	14
Strategy level pivots	8
Team level pivots	0

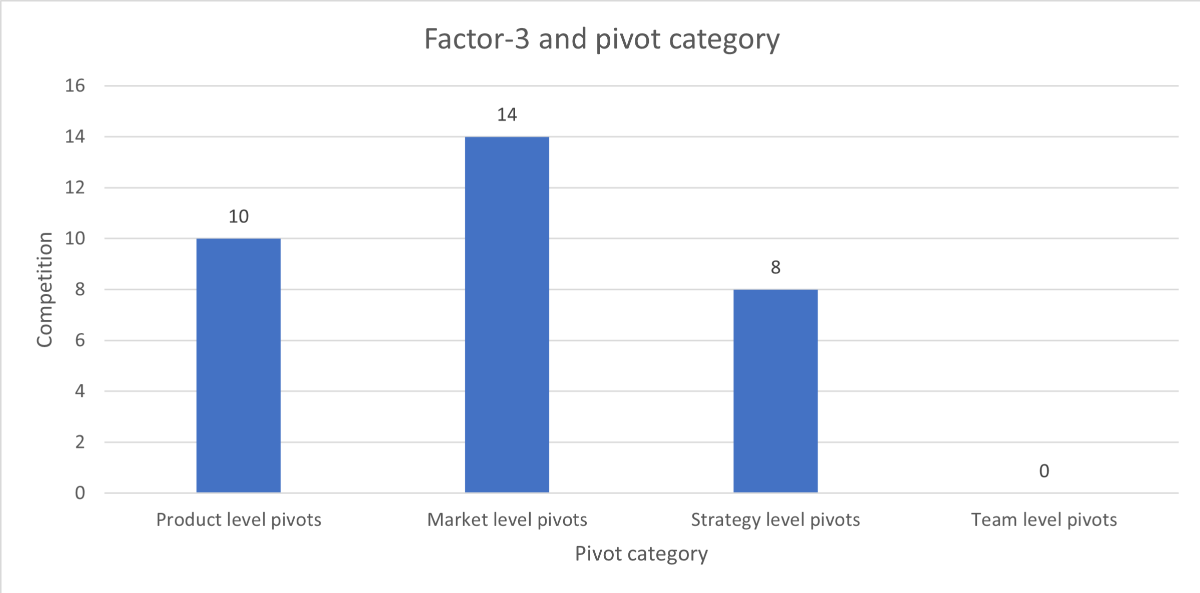

Figure 31. Frequency of pivot categories pursued by participants to address competition.

Table 14 detailed the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 4, i.e., Market conditions. Figure 32 depicts that market level pivots (N=15 times) were the most pursued pivots followed by strategy level pivots (N=5 times) by the tech entrepreneurs to address the factor called market conditions.

Table 14. Frequency of pivot categories to address market conditions (F-4).

Pivot Category	**Market conditions**
Product level pivots	5
Market level pivots	15
Strategy level pivots	7
Team level pivots	0

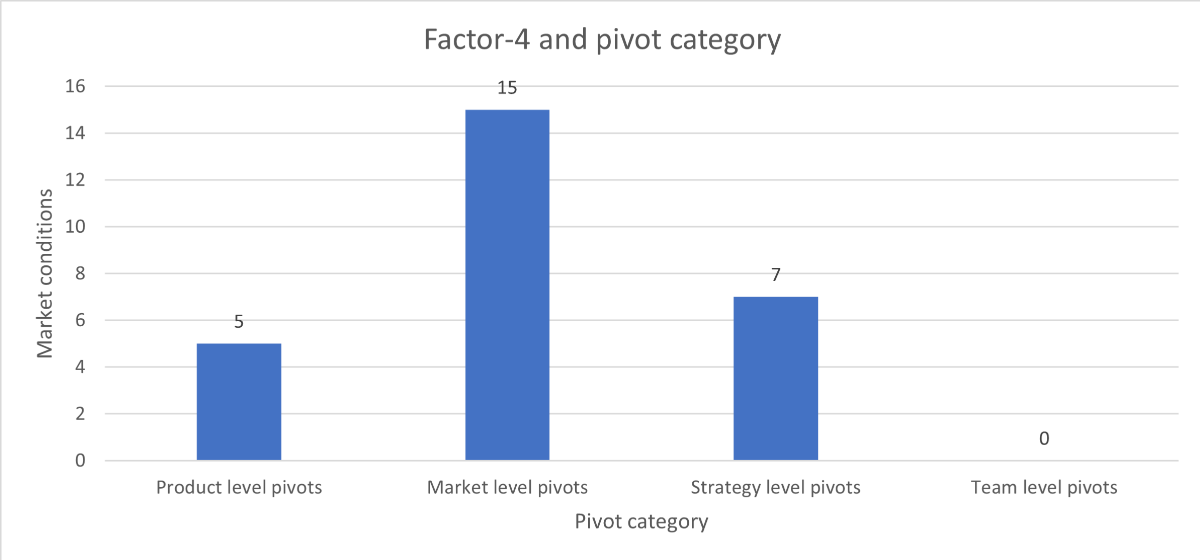

Figure 32. Frequency of pivot categories pursued by participants to address market conditions.

Table 15 detailed the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 5, i.e., unscalable business. Figure 33 depicts that market level pivots (N=7 times) were the most pursued pivots followed by product level pivots (N=3 times) by the tech entrepreneurs to address the factor called unscalable business.

Table 15. Frequency of pivot categories to address Unscalable business (F-5).

Pivot Category	**Unscalable business**
Product level pivots	3
Market level pivots	7
Strategy level pivots	2
Team level pivots	0

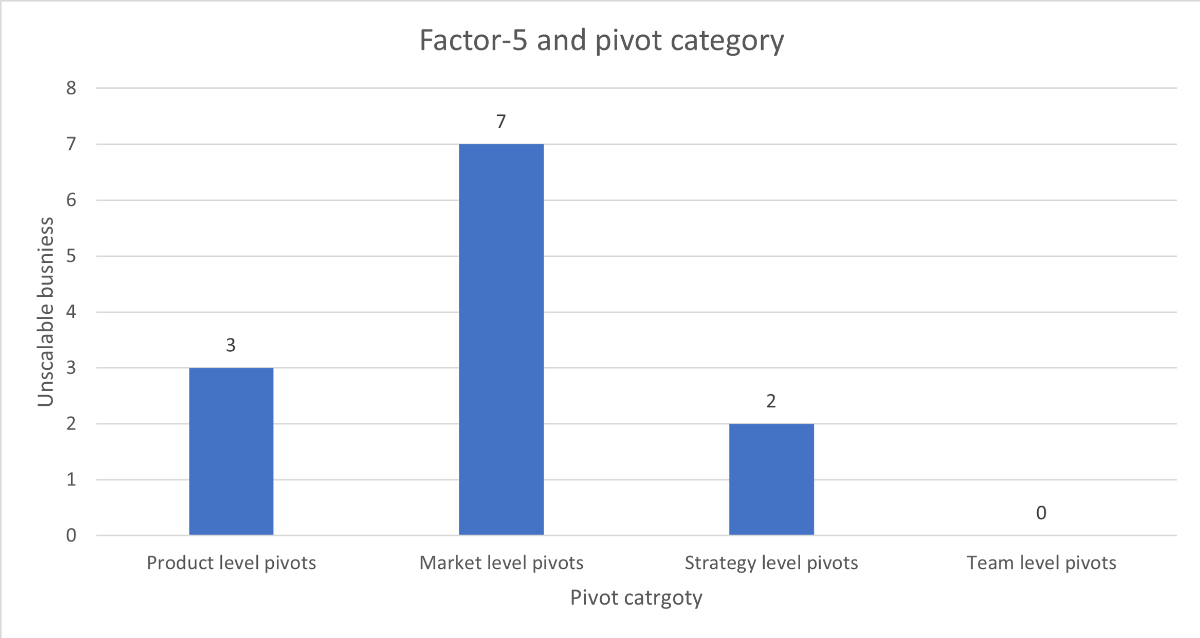

Figure 33. Frequency of pivot categories pursued by participants to address unscalable business.

Table 16 detailed the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 6, i.e., wrong timing. Figure 34 depicts that market level pivots (N=8 times) were the most pursued pivots followed by strategy level pivots (N=4 times) by the tech entrepreneurs to address the factor called wrong timing.

Table 16. Frequency of pivot categories to address wrong timing (F-6).

Pivot Category	**Wrong timing**
Product level pivots	2
Market level pivots	8
Strategy level pivots	4
Team level pivots	0

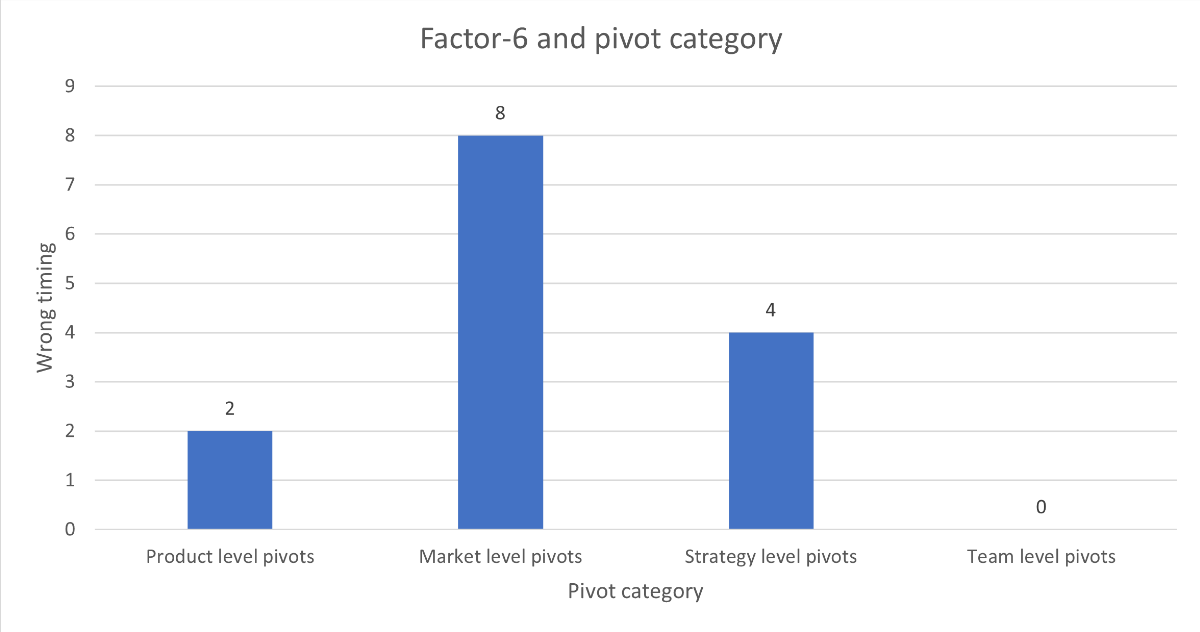

Figure 34. Frequency of pivot categories pursued by participants to address wrong timing.

Table 17 detailed the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 7, i.e., influence of investor, partner, or founder. Figure 35 depicts that market level pivots (N=12 times) were the most pursued pivots followed by strategy level pivots (N=9 times) by the tech entrepreneurs to address the factor called influence of investor, partner, or founder.

Table 17. Frequency of pivot categories to address influence of investor, partner, or founder (F-7).

Pivot Category	**Influence of investor, partner, or founder**
Product level pivots	3
Market level pivots	12
Strategy level pivots	9
Team level pivots	1

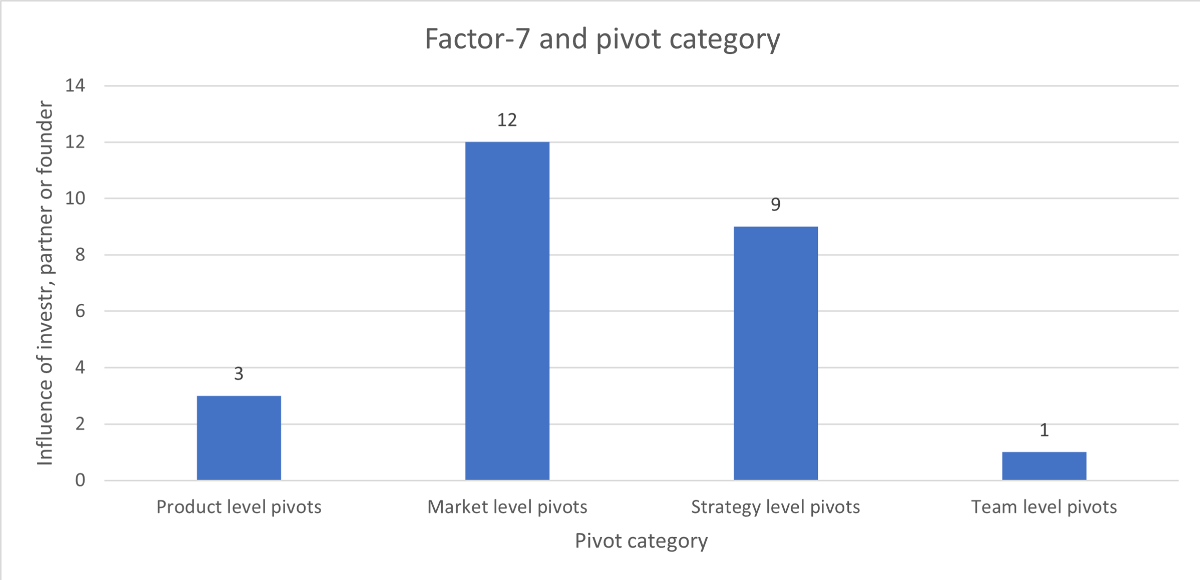

Figure 35. Frequency of pivot categories pursued by participants to address influence of investor, promoter, or founder.

Table 18 detailed the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 8, i.e., legal issues. Figure 36 depicts that product, strategy, and team level pivots (N=12 times) were the most pursued pivots by the tech entrepreneurs to address the factor called legal issues.

Table 18. Frequency of pivot categories to address legal issues (F-8).

Pivot Category	**Legal issues**
Product level pivots	2
Market level pivots	1
Strategy level pivots	2
Team level pivots	2

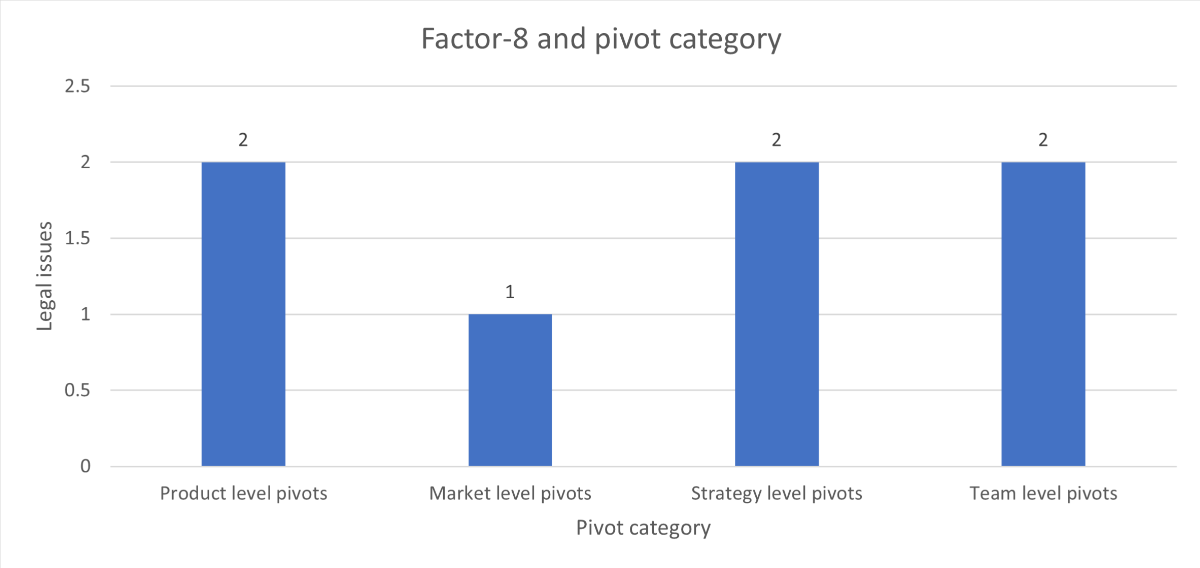

Figure 36. Frequency of pivot categories pursued by participants to address legal issues.

Table 19 detailed the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 9, i.e., flawed business model. Figure 37 depicts that market level pivots (N=4 times) were the most pursued pivots followed by product level pivots (N=3 times) by the tech entrepreneurs to address the factor called flawed business model.

Table 39. Frequency of pivot categories to address flawed business model (F-9).

Pivot Category	**Flawed business model**
Product level pivots	3
Market level pivots	4
Strategy level pivots	2
Team level pivots	1

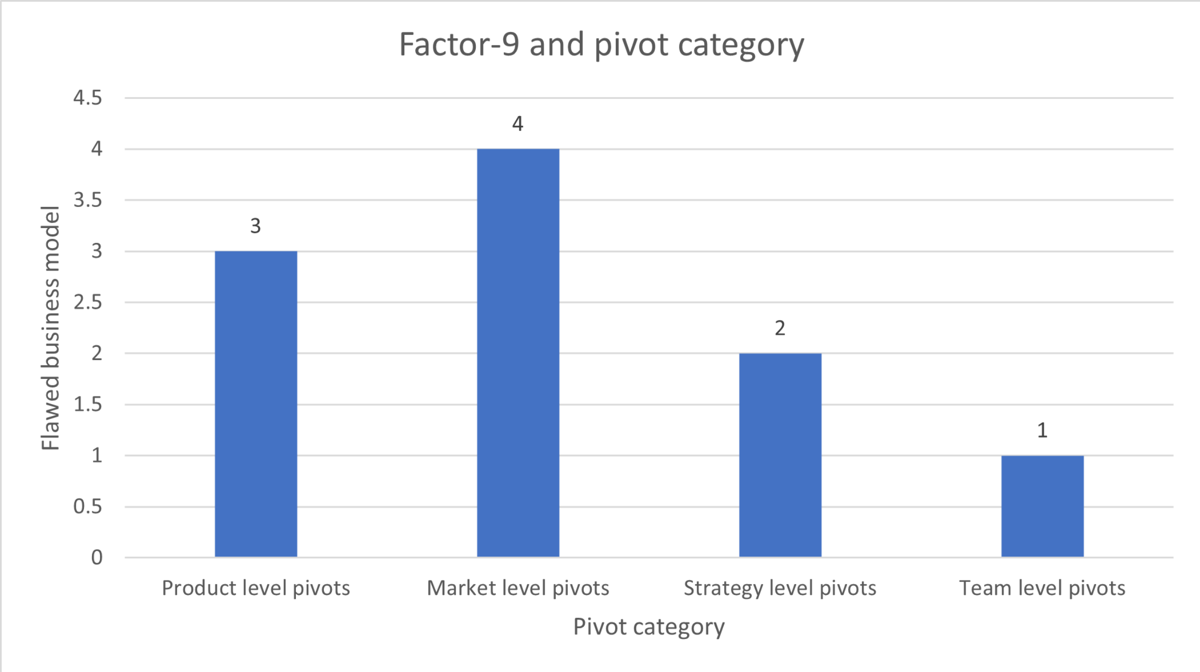

Figure 37. Frequency of pivot categories pursued by participants to address flawed business model.

Table 20 detailed the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 10, i.e., side project success. Figure 38 depicts that strategy level pivots (N=11 times) were the most pursued pivots by the tech entrepreneurs to address the factor called side project success.

Table 20. Frequency of pivot categories pursued to address side project success (F-10).

Pivot Category	Side project success
Product level pivots	2
Market level pivots	2
Strategy level pivots	11
Team level pivots	1

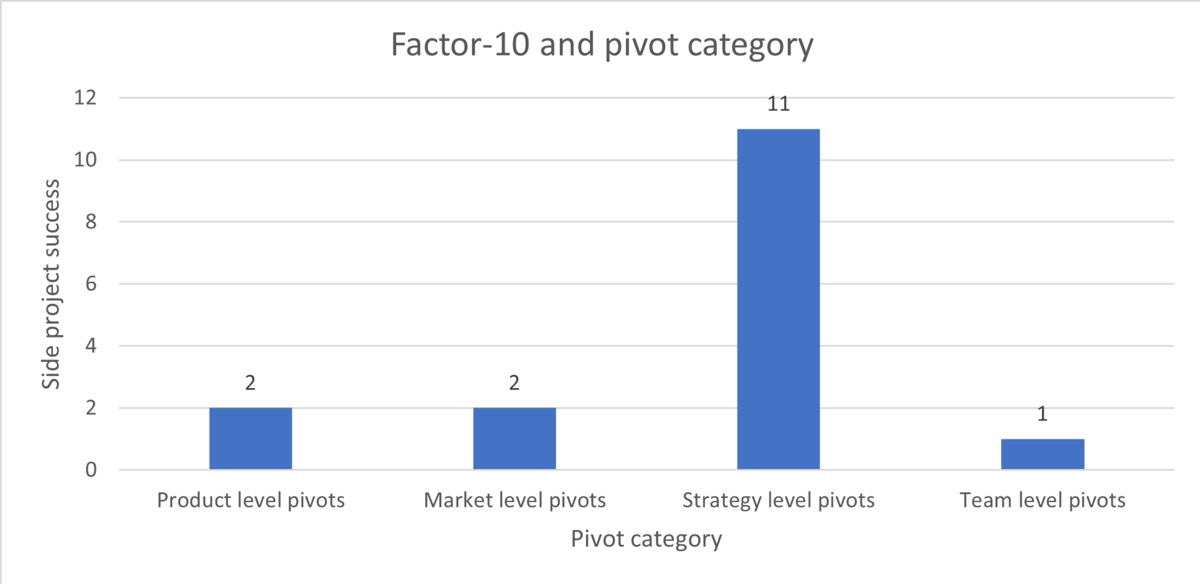

Figure 38. Frequency of pivot categories pursued by participants to address side project success.

Table 21 detailed the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 11, i.e., business financials. Figure 39 depicts that strategy level pivots (N=9 times) were the most pursued pivots by the tech entrepreneurs to address the factor called business financials.

Table 21. Frequency of pivot categories to address business financials (F-11).

Pivot Category	**Business financials**
Product level pivots	0
Market level pivots	1
Strategy level pivots	9
Team level pivots	1

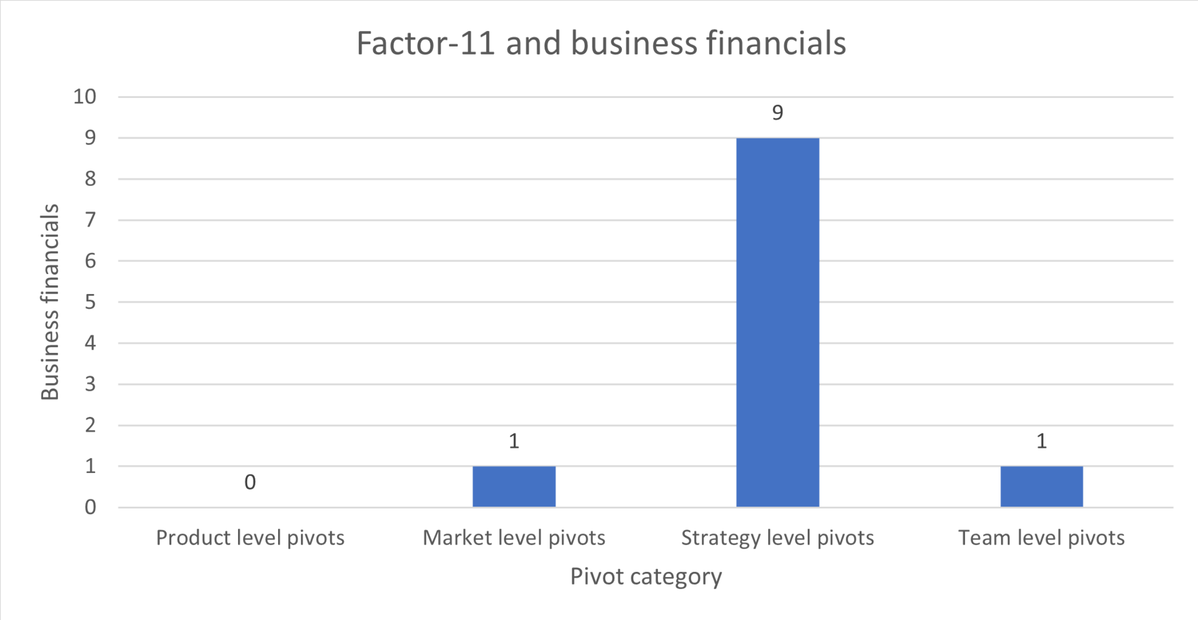

Figure 39. Frequency of pivot categories pursued by participants to address business financials.

Table 22 detailed the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 12, i.e., geopolitical issues. Figure 40 depicts that market level pivots (N=2 times) were the most pursued pivots by the tech entrepreneurs to address the factor called geopolitical issues.

Table 22. Frequency of pivot categories to address geopolitical issues (F-12).

Pivot Category	**Geopolitical issues**
Product level pivots	0
Market level pivots	2
Strategy level pivots	0
Team level pivots	0

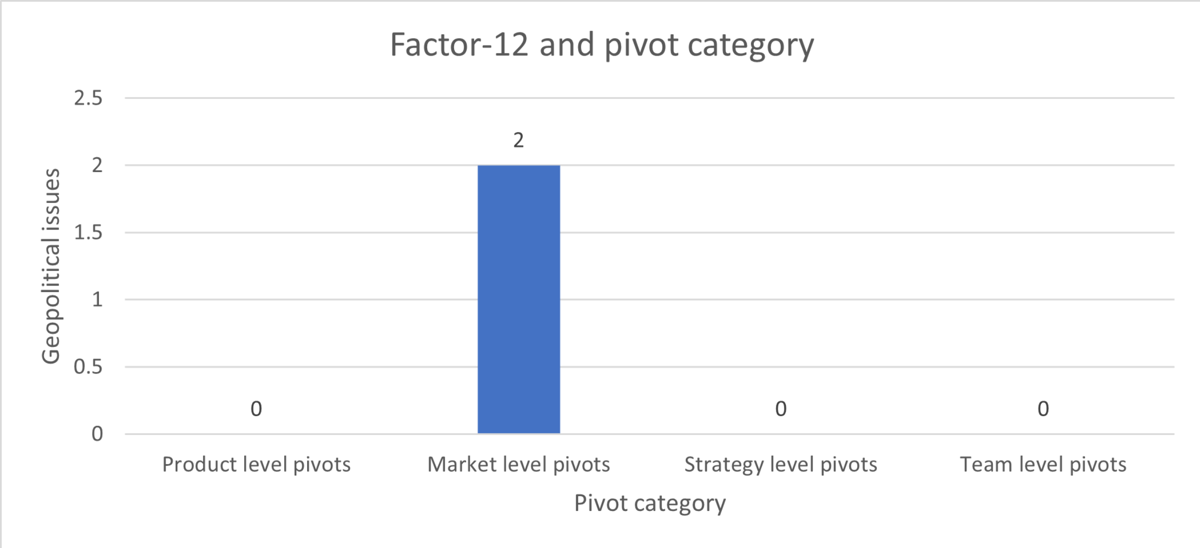

Figure 40. Frequency of pivot categories pursued by participants to address geopolitical issues.

Table 23 detailed the pivot type i.e., product level pivots, market level pivots, strategy level pivots, and team level pivots, with respect to factor 13, i.e., strategic longevity. Figure 41 depicts that product level pivots (N=3 times) followed by strategy level pivots (N=2 times) were the most pursued pivots by the tech entrepreneurs to address the factor called strategic longevity.

Table 23. Frequency of pivot to address strategic longevity (F-13).

Pivot Category	**Strategic longevity**
Product level pivots	3
Market level pivots	0
Strategy level pivots	2
Team level pivots	0

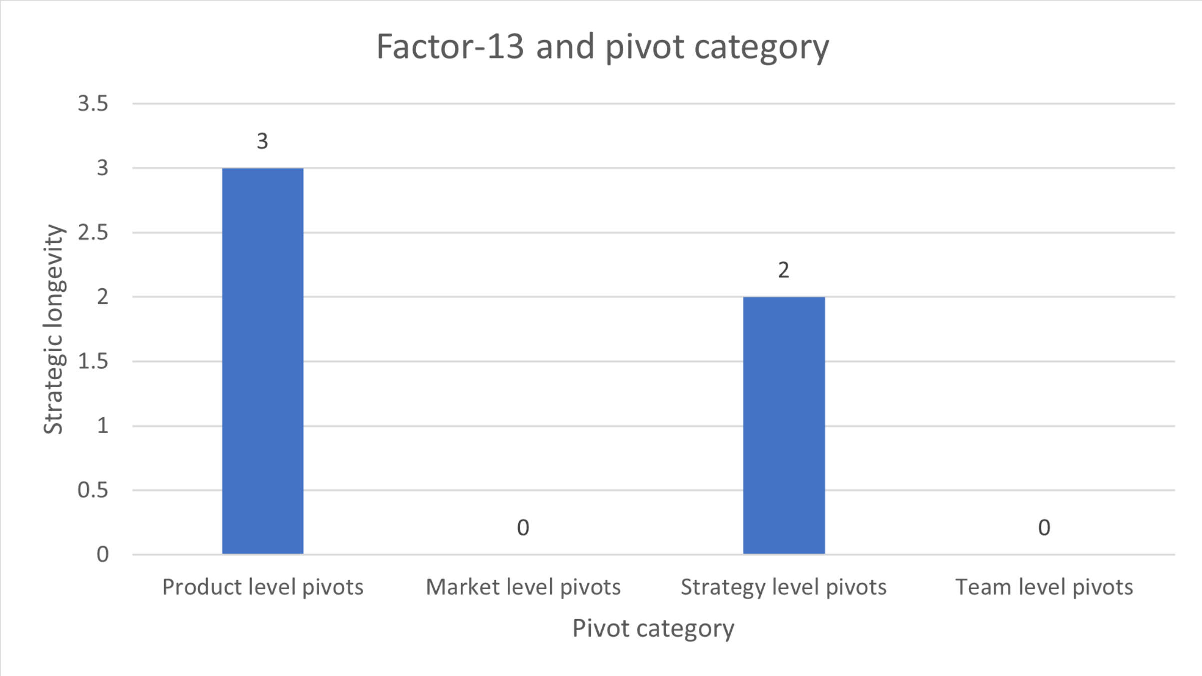

Figure 41. Frequency of pivot categories pursued by participants to address strategic longevity.

Table 24 summarises the factors and the frequency of pivot-level categories that were pursued against those factors. For example, to address the 'customer feedback' factor, the tech startups preferred to pursue mostly market-level category pivots followed by strategy-level pivots. Similarly, in the 'competition' factor, the tech startups opted mostly for market-level and product-level pivots.

Table 24. The most pursued pivot category against the factors.

Factors	**Product-level pivots**	**Market-level pivots**	**Strategy-level pivots**	**Team-level pivot**
Customer feedback	11	19	13	0
Technology challenges	8	5	5	0
Competition	10	14	8	0
Market conditions	5	15	7	0
Unscalable business	3	7	2	0
Wrong timing	2	8	4	0
Influence of investor, partner, or founder	3	12	9	1
Legal issues	2	1	2	2
Flawed business model	3	4	2	1
Side project success	2	2	11	1

Business financials	0	1	9	1
Geopolitical issues	0	2	0	0
Strategic longevity	3	0	2	0

6.4 Discussion

During their entrepreneurial journey, high-tech entrepreneurs may face a challenge that leads to a pivot from the original strategy (Ries, 2011). Pivoting means selecting a new path for creating value. The concept of pivoting leads to a new direction of research on entrepreneurship; it involves understanding the types of pivots pursued by high-tech entrepreneurs during their entrepreneurial journey. The qualitative analysis has sought to reveal new insights into the characteristics of pivots and the rationale behind pivoting as a core strategy to underpin startup survivability. Moreover, the study examined the consequences of pivoting in terms of how pivoting leads to the desired outcome for the startup and the challenges startups face while pursuing pivots.

Two new pivots, namely the 'business ecosystem pivot' and 'brand pivot', are identified as strategic-level pivots. Consequently, the study determined that sixteen pivots characterise the process of entrepreneurial pivoting. By Contrast, the study validated eleven factors identified from the literature review and two new factors were identified: 'strategic longevity' and 'geopolitical issue'. Consequently, the study determined that thirteen factors characterise the antecedent path that leads to the process of entrepreneurial pivoting. Furthermore, researchers such as Sadeghiani et al. (2021), Leatherbee and Katila (2017) and Grimes (2018) explained that pivoting can be viewed as a refinement of a business model or a creative revision of an entrepreneur's identity. The empirical analysis established that pivoting is not only a revision of an entrepreneur's identity. It is also a change in product or market, or strategy by a tech startup to meet the customer requirements.

The study has identified the most pursued pivots under each category of pivot levels. For example, the technology pivot is the most pursued pivot by the participants under the product-level pivots category. Similarly, in the case of market-level pivots, the customer segment pivot is the most adapted pivot by the participants. Finally, in the case of strategy-level pivots, the side project pivot is the most pursued.

The study has compared both primary and secondary data analysis and identified that the most pursued pivot in both data sets was the customer segment pivot. The top five pivots in the secondary data set came from market and strategy-level pivots. However, in the case of primary data, pivots were mainly from the market-level pivots category (three out of five), and the remaining two were product and strategy-level pivots. Nevertheless, the top five factors initiating pivots from both data sets differed. The most frequent factor in the secondary data was the flawed business model, followed by customer feedback and technology challenges. From the primary data set, the most frequent factor was customer feedback, followed by competition and market conditions.

The study has investigated whether there is a correlation between the factors and the pivots and could not find any substantial evidence to prove it. The study converted the qualitative data into quantitative data. The quantitative data is presented in Appendix IX. The data illustrates the frequency of pivots pursued by the interviewees against each factor but could not find any statistical significance to determine the correlation. The reason is that the quantitative data is insufficient to conduct a statistical analysis. Therefore, the study recommends collecting more quantitative data as one of the future research areas to determine the correlation between factors and pivots.

6.5 Conclusion

The previous studies by Sadeghiani et al. (2021), Hampel et al. (2020), Garcia-Gutierrez and Martinez-Borreguero, (2016), Grimes (2018), and Bohn and Kundisch (2018) on entrepreneurial pivoting been focused on understanding a) how pivoting affects the relationship between entrepreneurs and stakeholders; b) new ideas by testing different hypotheses; c) pivoting for achieving viable business models, d) how pivoting changed the small business. However, there are few studies on the types of pivoting and the factors that trigger pivoting. The studies from Ries (2011) and Bajwa et al. (2017) discussed the types of pivots and the factors that trigger pivoting. Bajwa et al. (2017) used secondary data to understand the factors that trigger pivoting and the types of pivots pursued by startups. By contrast, a research study by Bohn and Kundisch (2018) studied only one pivot, i.e., the technology pivot. Consequently, in the extant literature there is a distinct gap in the knowledge base through there being a lack of empirical studies based on primary data collection that have substantiated and validated the types of pivots and the factors that cause such pivots. Therefore, and based on the work of Ries (2011) and Bajwa et al. (2017), this research study has collected primary data through interviews and applied qualitative data analysis to validate all types of pivots and the factors that trigger pivoting. However, the study found no evidence of a correlation between the factors and pivots.

As mentioned at the beginning of this chapter, the results and discussion on the primary thirty interviews are divided into two parts 'a' and 'b'. In the first part, the study discussed different types of pivots and the factors that trigger those pivots. In the second part (i.e., part b), the study will discuss the influence of TE phases on pivoting and the impact of stages of technology in the technology S-curve on pivoting. The study will also explain how it has found supporting evidence for the studies of Ries (2011), Hirvikoski (2014), Flechas Chaparro and de Vasconcelos Gomes (2021), and McMullen (2017), which illustrated that startups change their course of direction to test new hypotheses. The study will also discuss the domino effect found in pivoting and the challenges tech startups face during pivoting.

Chapter 7: Results and discussion (Primary data: First thirty interviews – part b)

7.1 Introduction

Technology entrepreneurship (TE) is a prominent theory in the entrepreneurship literature. For example, Schumpeter (1942) explained that entrepreneurs develop market-fit products by exploring new combinations of resources. Similarly, Beckman et al. (2012a) mentioned that TE is a convergence of entrepreneurial opportunities and technological innovation. Spiegel and Marxt (2011) defined TE in three phases: Formation, Exploitation and Renewal. In the first phase, the tech entrepreneur assembles the resources and technical systems to recognise the opportunities or ideas. Once an opportunity is recognised, the tech entrepreneur explores the idea with the help of resources and technical systems. This is the second phase in TE. The third phase involves adapting to customer requirements and re-releasing the product or service.

A technology's performance has been observed to initially be slow, then a rapid growth occurs followed by a slow decline, thereby resulting in an S-shaped curve. In the 1960s, the S-curve model and envelope curves were used to understand technological forecasting. The technology S-curve describes technology developments in a product or platform design over a period. It can be observed that while the technology s-curve is a mature area of study, it has yet to be applied to the concept of entrepreneurial pivoting.

This chapter will cover the empirical results of thirty primary interviews to present the impact of the phases of technology entrepreneurship, the influence of the stage of technology in the technology S-curve on pivoting and other emerging phenomena that the study identified through qualitative data analysis.

7.2 Understanding the impact of the phases of technology entrepreneurship on pivoting

The research study focused on identifying the impact of the technology entrepreneurship phases (i.e., Formation, Exploitation and Renewal) on pivoting. Overall, fifty-seven percent of participants (N=17) agreed that the phases of technology entrepreneurship impact pivoting. Whereas thirty percent (N=9) of the interviewees disagreed. However, thirteen percent (N=4) of participants were not sure whether the phases of TE influence pivoting or not. Figure 42 illustrates the results. Furthermore, thirty-four percent (N=10) of tech entrepreneurs pointed out that they do not recognise the TE framework by Spiegel and Marxt (2011). Participants felt that the simple linear process of formation, exploitation and renewal did not fully capture the complex nature of TE. They believed that the TE framework needs to have a feedback loop because it is not always a simple linear process and instead relates to a more complex phenomenon.

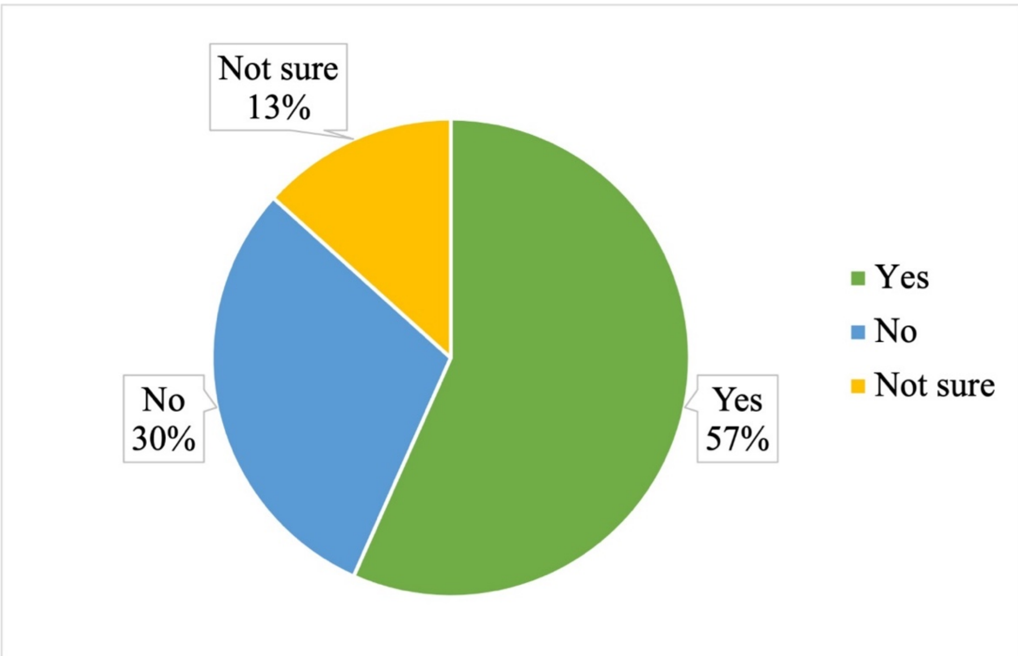

Figure 42. Participants response on influence of TE phases on pivoting.

The following are selected quotes by the interviewees who agreed that yes, the phases of technology entrepreneurship influences pivoting. Participant 8 said, *"I think second, and third phases definitely have an impact. First phase I am not very sure, but I think all of them have at some level* [*sic*]*."*

Participant 11 mentioned, "*I think each phase promotes a different type of pivot your last phase promotes markets and commercial pivots, you will the second phase promotes technology development and legal pivots. Yeah, you know, I would say that you have different pivots depending on the phase you are* [*sic*]".

Participant 2 expressed, "*I think sooner rather than later because in future you go down the more difficult to get some pivot* [*sic*]".

Participant-3 said, "*I do think so. We were kind of running several parallel tech startups. I know it sounds like a weird thing to say, but we were at various stages of formation, exploitation, and renewal, and we put several of them down and what phase are at does affect the way that you pivot for sure. It also affects your freedom to pivot* [*sic*]".

Participant 3, who agreed that phase of TE influences pivoting, mentioned that the interviewee does not recognise the existing framework of TE by Spiegel and Martx (2011). The participant's quote is as following: *"I do not recognize this phased structure. It's not a structure that I've that I really recognize, and the reason is if you think about growth this is this kind of assume steady state and if you are growing as a business, then you are always in formation and exploitation and renewal. So, like you are in all three phases continually* [*sic*]*."*

The following are some quotes from participants who did not agree that phases of TE influence pivoting: Participant 28 said, "*Yeah, I think every one of those phases. If you are learning new things and responding to what's happening externally, then I think yeah* [*sic*]".

Participant 25 expressed similar to what participant 28 had mentioned in above statement i.e., "*Of course, it can be done at any stage* [*sic*]".

Participant 30 mentioned, *"A pivot could happen to any one of these phases for different reasons* [*sic*]*."*

The other participants (i.e., Participants 1, 4, 5, 7, 8, 9, 17, 19, 26, and 27) who agreed that the phases of technology entrepreneurship influence pivoting answered the question by saying *"yes", "it does", "yes, absolutely", "I would say, yes"* or *"in our case, yes"*. By Contrast, nine participants (i.e., Participants 10, 12, 15, 22, 23, 24, 25, 28 and 30) did not agree that the phases of TE influence pivoting.

7.2 Understanding the influence of the stage of technology in the technology S-curve on pivoting

The interviews also focused on understanding pivoting experience and whether technology maturity or the stage of technology in the technology S-curve impacted pivoting. During the interviews, the participants who responded that technology maturity influences pivoting were further questioned: At what stage of the technology S-curve did their tech startup pivot?

Table 25 illustrates the participants' responses on the influence of technology maturity on pivoting, whether they changed the technology after pivoting, and the stage of technology in the technology S-curve at which their tech startup first pivoted. All the participants shared details about a single startup, apart from Participant 28, a non-executive director with twenty-three years of experience in the technology industry, who shared pivoting experience of three companies.

Table 25. Responses of study participants (tech entrepreneurs).

Participant ID	Technology S-curve influence on pivoting (Yes/No/Not Sure)	Technology S-curve stage at the time of pivot	Change in technology after pivoting (Yes/No)
1	Yes	Introduction stage	Yes
2	Yes	Introduction stage	No
3	Yes	Introduction stage	No
4	Yes	Introduction stage	Yes
5	No	N/A	No
6	Yes	N/A	N/A
7	Yes	Introduction stage	Yes
8	Yes	Growth and decline stages	Yes
9	Yes	Introduction stage	No
10	Yes	Introduction stage	No
11	Yes	Introduction and growth stage	Yes
12	No	N/A	No
13	Not Sure	N/A	Yes
14	No	N/A	No
15	Yes	Growth and maturity stage	Yes
16	No	N/A	No
17	Yes	Introduction and growth stage	Yes
18	Not Sure	N/A	Yes
19	Yes	Introduction stage	No
20	Yes	Introduction stage	No
21	Not Sure	N/A	No

22	Yes	Introduction stage	No
23	No	N/A	N/A
24	No	N/A	Yes
25	Yes	Introduction stage	No
26	Yes	Growth stage	No
27	Yes	Introduction stage	No
28	Yes	Company-A: Introduction stage, Company-B & C: Maturity stage	Yes
29	Yes	Maturity stage	Yes
30	Yes	Introduction stage	No

The qualitative data analysis explored the tech entrepreneur's viewpoint on pivoting and the technology S-curve framework. Table 25 illustrates the responses of the participants on whether the stage of technology in the technology S-curve influence pivoting or not. The data analysis shows that seventy percent of tech entrepreneurs (N=21) agreed that technology maturity influences pivoting. These participants explained their overall experience of pivoting with respect to technology maturity rather than linking it with every single pivot they pursued. By Contrast, twenty percent of interviewees (N=6) did not agree that the stages of the technology in the technology S-curve influenced their pivoting decision. Furthermore, ten percent of the interviewees (N=3) could not confirm whether the technology stage in the technology S-curve influence pivoting decisions or not.

Figure 43 shows the number of participants from each sector who agreed or disagreed or were unsure about the influence of technology maturity on pivoting. For example, 80% (i.e., eight of ten) of the tech entrepreneurs working in the internet technology sector agreed that the stage of technology in the TLC influences pivoting. By Contrast, 67% (i.e., six out of nine) of participants agreed in the software technology sector. In addition, 60% (i.e., three out of five) from other electronics-related technologies, 75% (i.e., three out of four) from biotechnology, medical, instrumentation and medical pharmaceutical technology, and one (50%) from communication systems technology accepted the same. This highlights that there is some variability across the sectors on the proportion of tech entrepreneurs that believe that the stage of technology in the TLC influences pivoting, although this finding is tentative due to the limited sample size for each sector.

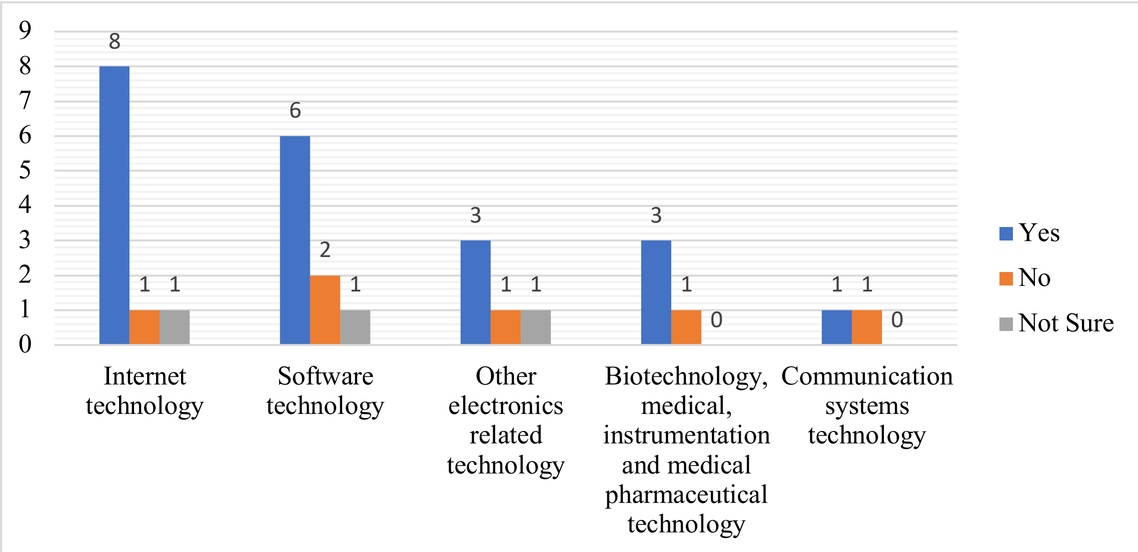

Figure 43. Responses of participants from each technology sector about influence of technology S-curve on pivoting.

The entrepreneurs who agreed on the influence of technology maturity expressed the view that startups should recognize that technology can be eclipsed, and therefore the startup needs to be ready to change direction accordingly. They further explained that technology maturity can have a significant impact on pivoting. For example, participant 10 mentioned that their tech startup had to pivot because the underlying technology was not widely available "*So, in our case the fact of not having widely available virtual reality has actually impacted our I guess pivot* [*sic*]."

Participant 22 expressed the view that there is a need to assess what is happening in the marketplace and constantly adapt to technology to the changing circumstances: "*Yes, because I am back to square one. We constantly reviewing what is going on the marketplace* [*sic*]."

Similarly, participant 28 mentioned that if a technology does not grow in terms of performance or is in either the maturity or decline stage, tech startups tend to pivot to do something different and avoid pressure from investors. In this regard participant 28 said: "*If you are not seeing the growth that you wanted to. If you are not capturing market share, there is incredible pressure particularly from investors to do something different, which also may drive pivoting* [*sic*]."

Participant 29 stated that for every tech startup, technology development is a learning process, which helps in the development of a company. An example provided by participant 29 is how large companies in the automobile industry invest heavily in hybrid engines and electric car development because the technology in the internal combustion engines is in the early decline stage of the technology S-curve. Furthermore, participant 29 mentioned, "*If you think of the large car manufacturer like ******* obviously their technology in the let's face it is at the beginning of decline stage at the moment the internal combustion engine and now they are having to pivot to an electric motor which is about 30 or 60 billion dollars* [*sic*]." It should be noted that in the above quotation the name of the company has been anonymized to maintain confidentiality.

Even though participant 6 did not pivot, the tech entrepreneur mentioned that the technology they are using to develop the startup's main product is more suitable for desktops and laptops. However, they need to make sure that the product also works well on mobile or small screen devices, and therefore they need to change the fundamental technology, which will likely lead to pivots in the near future. In regard to other participant responses on whether technology maturity influences pivoting, participant 3 mentioned "*Yeah in a really big way, especially with what we are doing now* [*sic*]."

Similarly, participant 11 expressed the view "*Oh, yeah. Yeah. Yeah, now I absolutely I think you know because it is a technology timeline were talking about you. I feel like it is very much. It will have a greater impact actually* [*sic*]."

Participant 12 spoke on this matter and said "*Yes, it does affect pivoting. For me okay looking at the holistically yes, it does affect pivoting* [*sic*]." Therefore, the research study has identified that technology maturity and the corresponding stage of the technology in the S-curve has an influence pivoting by the tech entrepreneurs.

Even though 70% (N=21) of the tech entrepreneurs in the interview agreed that the stage of technology in the technology S-curve influences pivoting, six interviewees (20%) i.e., two tech entrepreneurs from the software technology sector and one tech entrepreneur each from the remaining technology sectors did not agree that the stage of the technology in the technology S-curve influences their pivoting decision. Furthermore, 10% (N=3) of the total interviewees could not confirm whether technology maturity influences pivoting decisions or not. For example, participant 16 expressed the view that the most important issue for any tech startup is the level of demand from customers, and so it does not matter what technology or how the technology is changed if the demand of customers is addressed. Moreover, participant 5 spoke about the matter and mentioned "*I do not really think so because I think if you wait for one of these stages to affect it to make it think about pivoting you might be too late. That is why* [*sic*]." Consequently, although a majority of participants in the interviews believed there was an influence of technology maturity on startup pivoting it is acknowledged that not all of the participants believed this to be the case.

7.2.1 Change in the technology due to pivoting

The study was concerned to identify whether pivoting leads to a change in the technology used by the tech startup. Upon analysis of the data, twenty-nine tech entrepreneurs answered this question out of thirty participants, whereas participant 6 could not answer the question as the tech entrepreneur did not pursue a single pivot, and hence could not answer.

Out of the twenty-nine participants, fifty-seven percent of the tech entrepreneurs (N=16) felt that pivoting does not lead to a change in the underlying technology of the tech startup. For example, participants 2, 3, 5, 9, 10, 12, 22 and 27 mentioned that the core technology used by their tech startups did not change, but it has evolved over time.

Participant 2 stated "*Yeah, a lot more features a lot better, you know some but yet it's still no the tech, the concept, the principal's they are same* [*sic*]."

Participant 9 said on the matter "*Yeah has not changed the technology. Obviously, it's adapted a little bit, but no, it has not changed it* [*sic*]."

Participant 12 mentioned "*The core technology has been the same. We have added all the time with starts to use for the technology, but the core foundations, core blocks that we build on, remained the same* [*sic*]."

Conversely, forty-three percent of the interviewees (N=12) agreed that pivoting leads to a change in the underlying technology of the tech startup. For example, participant 28 commented "*In case of company B yeah, I mean there was a real shift in what the core technologies for the business* [*sic*]."

Similarly, participant 17 said "*Each of these pivots were rebuilt it from scratch. We rebuild it from brand new technology* [*sic*]."

Participant 8 explained "*Yes, definitely. First of all, it was just a social platform rather than being an artificial intelligence company. It was just it so at the start yes it was a social citizen journalism social platform where only people were doing stuff posting stuff in the more sort of forum type of way, but later on when we introduced AI and then pivoted to AI so once for so I would say for one pivot yeah* [*sic*]." Therefore, the research study could not establish strong evidence that pivoting leads to a change in technology used by a tech startup.

7.2.2 Identifying when pivoting occurs according to the technology S-curve

The study also focused on understanding the most common stage of the technology S-curve where tech startups pursue pivot(s). Figure 44 provides details on the percentages of participants who pivoted at a particular stage of the technology S-curve. These are the participants who also agreed that technology maturity influences entrepreneurial pivoting. The qualitative data analysis results showed that 62% (N=16) of the tech startups pursued pivots when their underlying technology was in the introduction stage. The second-highest number of pivots were performed when the technology was in the growth stage i.e., 19% (N= 5). In comparison, the maturity and decline stages are where 15% (N=4) and 4% (N=1) of the interviewees pursued pivots respectively. During the interviews, the tech entrepreneurs explained that the earlier they pivot, the more cost-effective it will likely be for the tech startups.

For example, Participant 20 remarked "*Introduction because you're trying to meet the customers' needs and then grow* [*sic*]." Similarly, participant 2 explained that "*Well, definitely not the decline stage. Not the decline. So, I guess it probably at the earliest stages. It depends how long it is going to take to route to market* [*sic*]."

Some participants mentioned that the introduction stage is the most obvious one to pursue a pivot because the focus of tech startups in the initial phase is to match the customer requirements. Indeed, some tech entrepreneurs prefer to be early adopters of the technology since it may be more painful, expensive, time-consuming, and harder to realign and change resource allocation in the later stage of the technology S-curve i.e., when the technology is more mature.

In this case, participant 30 commented "*Yes, the later the stage in cycle the harder the pivot is and the harder it will be to pivot the bigger the challenge* [*sic*]." In addition, participant 30 said that "*The entrepreneur would want the pivot when it is appropriate, but it is harder to realign* *and change resource allocation the later if you are in the decline stage, then there are all really well-established processes. They are already so much built-in requirements built into your system. Well, there is going to be a massive challenge and people will balance out* [*sic*].” Furthermore, participant 29 expressed the view that “*If they are committed to investing something like 30 to 60 billion dollars in essentially pivoting to a new technology, right and probably new channels and all of them. So that is only one pivot, but it is enormous and expensive and very public and time-consuming said* [*sic*].” Therefore, the study identified relatively strong support for the notion that tech startups are most likely to pivot when the startup’s main technology is in the introduction stage of the technology S-curve.

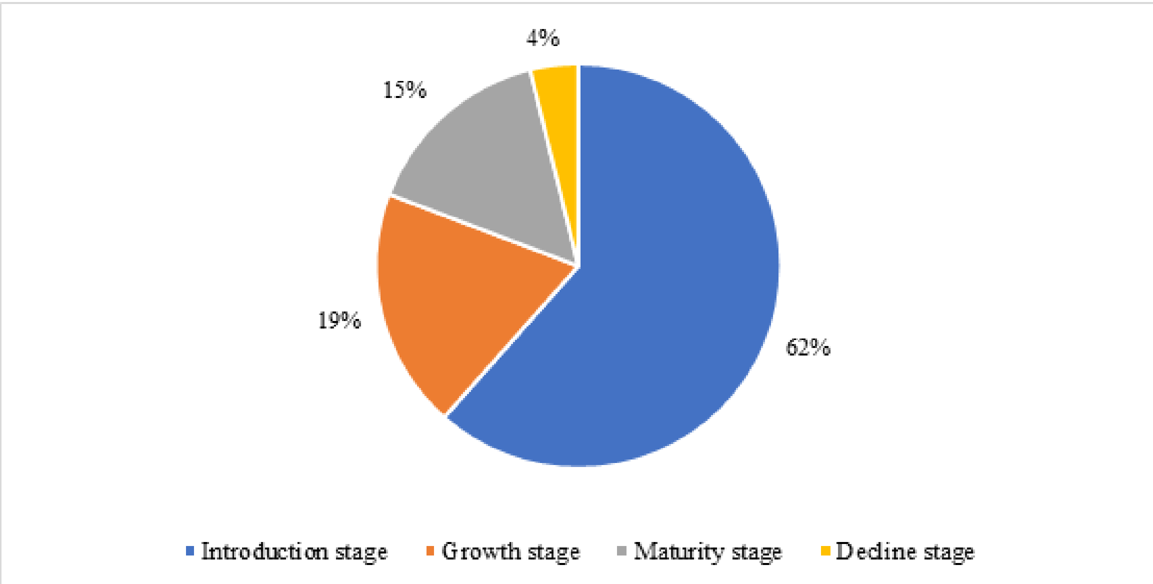

Figure 44. Percentage of tech entrepreneurs that pivoted at each stage of the technology S-curve.

7.3 Realising the value proposition through pivoting

One of the motivations behind investigating entrepreneurial pivoting is to understand whether pivoting helps to create and sustain the venture’s value proposition. Eighty percent of the participants (N=24) agreed that yes, pivoting helps in creating and sustaining a value proposition. By Contrast, twenty percent of the participants (N=6) could not confirm this point. However, they did not deny that pivoting helps in creating a value proposition. The participants further explained that startup business plans often encounter difficulties, and it subsequently becomes essential to pivot for the company's survivability. Figure 45 is a pie chart that illustrates the responses of tech entrepreneurs' on whether they agree or not that pivoting helps in creating or sustaining value proposition.

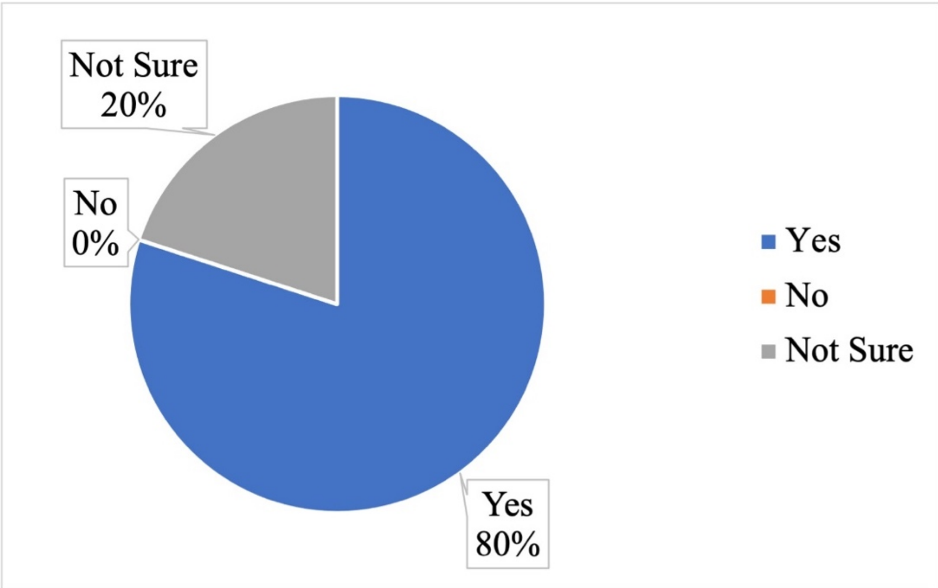

Figure 45. Participants response about creating and sustaining value proposition through pivoting.

Therefore, the qualitative analysis found strong evidence to support the seventh research question that pivoting creates and sustains a value proposition, which is illustrated through the following participant quotations.

Participant 2 explained, *"Yes, on numerous grounds because the first business plan usually wrong and even after pivot basically know that there is so much additional thing. So yeah, absolutely. It is a continuous progress and any startup that has not pivoted I am very suspicious so that is my sort of experience* [*sic*]*."*

Participant 6 shared view on value proposition by saying, "*Yes, I think all startups actually are pivoting while they will grow as a business. Otherwise, it is not possible to create a good value proposition for your client* [*sic*]*"*.

Participant 20: *"I have not been in a business yet where we have not had to make minor or major pivots and you know, I have been in three companies and each of them has had to pay because things change, you know, technology changes, customer needs change, competition changes you need be tuned in and listening to what is happening* [*sic*]*."*

Participant 27 explained that the answer to whether pivoting helps in creating and sustain value proposition is yes. The tech entrepreneur mentioned that *"The obvious response that sounds like yes. You know the key to getting a new business off the ground is the sort of cliche of product-market fit and finding a segment within you know, your niche or your industry or your service where you know, you gain traction and where you can grow at a cost-effective sustainable rate* [*sic*]*."*

Whereas participant 18 who was not sure that pivoting is essentially leads to value proposition mentioned, *"I would say that to change direction to maintain the value propositions is probably not right because that suggests that you will absolutely nail down on the value proposition and that is the only thing that you are going to do*[*sic*]*."*

Participant 21 shared the similar view as the above participant, *"I would not say it is essential I would say it is something to be mindful of and be aware of that. That is a something that can happen* [*sic*]*."*

Both the participants (i.e., 18 and 21) were unsure whether pivoting leads to the value proposition. They believed startups do not pivot exclusively to create and sustain value propositions.

7.4 Emerging pivoting phenomena

While researching entrepreneurial pivoting, the study identified three further aspects related to pivoting. They are: (a) the domino effect; (b) pivoting leading to the achievement of the desired results; and (c) the challenges faced by startups while pursuing pivots.

7.4.1 Domino effect

In regard to point (a), the study found that there can often be a domino effect in pivoting, which has been previously reported in the studies by (Terho et al., 2015). Sixty-seven percent of high-tech entrepreneurs (N=20) confirmed the domino effect, and twelve interviewees shared their experiences about how one pivot triggered another pivot. The remaining thirty-seven percent of participants (N=10) did not experience the domino effect in their entrepreneurial pivoting journey. Figure 46 illustrates the list of pivots pursued by twelve participants due to the domino effect. Out of the 12 participants, three interviewees shared two cases of the domino effect. Four participants pursued triple pivots due to the domino effect, and the rest of them pursued double pivots. For example, participant 4 explained the sequence of pivots that the tech startup pursued. In this case, the market segment pivot led to the customer need pivot, and the customer need pivot led to the channel pivot. Similarly, participant 5 mentioned that their tech startup had first pursued a zoom-in pivot, leading to a zoom-out pivot and a zoom-out pivot leading to a customer segment pivot.

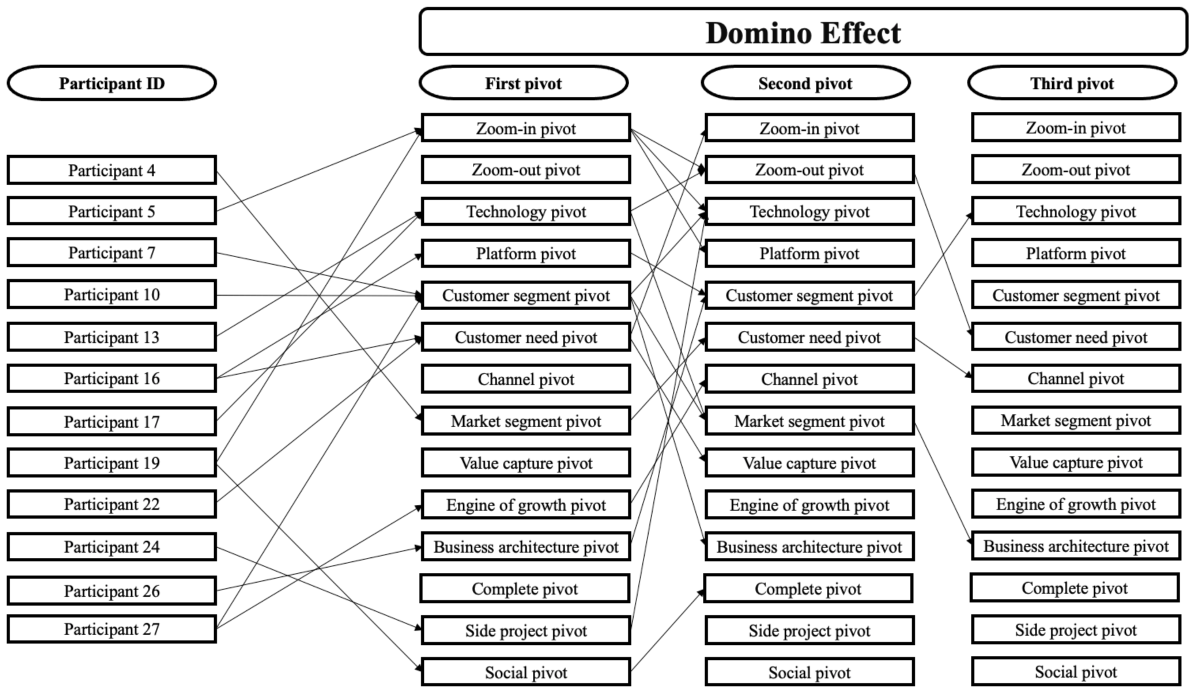

Figure 46. Domino effect in pivoting identified by study participants.

The following are selected participant quotations related to the domino effect in pivoting:

Participant 10 expressed that, *"I guess, you know that they are absolutely totally related to each other. But I guess it is hard to say what came first* [*sic*]*."*

Participant 11 mentioned, *"Absolutely. I mean when you change from hardware to software the whole market changes you know your approach to market changes that there is a whole bunch your whole business model changes effectively when you move hardware to software* [*sic*]*."*
Participant 12 explained, *"I think every pivot has sort of been related because it has been the evolution of the company and the product. Yeah, that is definitely say every pivot is related is a domino effect, and it has been the evolution of products* [sic]*."*

Participant 13 mentioned, *"The feedback I would give you is that they (pivots) do not often come on their own. So, it is very seldom that you get just one of these happening you will get another, for example, number 3 (technology pivot), number 8 (market segment pivot) and number 11 (business architecture pivot) you will get a grouping of these* [*sic*]."
Similarly, participant 16 said, *"Yes, they do. So, platform pivot actually let us to Customer segment pivot and Technology pivot, and I think Customer need pivot led us to Zoom-in pivot* [*sic*]*."*

Participant 17 shared the experience of domino effect, *"Yes, definitely. Technology pivot led to zoom-out pivot and zoom-out pivot led to customer need pivot* [*sic*]*."*

Participant 24 shared that, *"I think that there is definitely some overlap. Yeah, so I think the customer segment pivot and business architecture pivot were quite linked. I think our engine of growth and channel pivots were linked as well* [*sic*]*."*
The quotes from the participants provide evidence of experiencing the domino effect of pivoting by the tech startups. The participants shared examples of pursuing multiple pivots by their tech startups.

7.4.2 Pivoting helps to achieve the desired results

During the interviews and in regard to point (b), the interviewer asked participants whether pivoted help the startup to achieve the desired results. Ninety percent of the participants (N=27) agreed that yes, they achieved the desired results after pivoting. Three participants mentioned that they are yet to achieve the desired results, but the preliminary results were positive. This substantiates the point that pivoting eventually enables high-tech entrepreneurs to find the right direction for their tech startups.

The following are selected participant quotations about whether pivoting helped in achieving desired results or not according to their experience:

Participant 9 said *"Yes. I mean in some ways it is still ongoing but yes, we did achieve results [sic]."*

Participant 13 explained his views as, *"If I look at more historical that pivots that I've done then generally Yes, they have found their way forward. You know pivoting is really a key thing that success. So yes, in the past but the current situation is still ongoing* [*sic*]*."*

Here is the conversation between the interviewer and Participant 19 about startup achieved results after pivoting, Participant 19 *"Desired results no, results yes. Desired results would have been stick to initial plan* [*sic*]*."*

Interviewer *"I mean reason for which your startup pivoted, have you achieved it or not* [*sic*]*."*

Participant 16 *"Yes* [*sic*]*."*

Participant 24 said that *"Yes for those pivots that we had pursued because we had it, we will pivot again. Sometimes, it was not one pivot, it was multiple pivots*[*sic*]*."*

Another example to support that pivoting helps in achieving desired results is the experience of participant 30. The tech entrepreneur mentioned that *"Yes, it did. The desired results from the pivot was to have an investable business to attract our first investment and to make it compelling to build a compelling narrative around what we were doing and yes, we did we manage to attract investment* [*sic*]*."*

Similarly, participant 9 shared experience about pivoting and achieving results. According to the interviewee, not all pivots lead to desirable results. Participant 9 mentioned that *"I think we have had more success with the first and third pivots* [*sic*]*."*

The quotes mentioned above are examples of participants sharing their viewpoints on whether pivots help to achieve the desired results. However, there were instances where specific pivots did not lead to the intended results for the tech startups.

7.4.3 Challenges faced by tech startups due to pivoting

A tech startup drives forward to develop a product-market fit for its customers and the company will often pivot to achieve this goal. However, it is not necessarily easy or straightforward to change the direction of a tech startup. Upon discussion with the interviewees, the study identified the challenges faced by tech startups and classified them into three groups: i) persuading customers; ii) securing the agreement of stakeholders, partners, or suppliers; and iii) onboarding resources. The study found that the high-tech entrepreneurs faced at least one of the above three challenges when trying to pivot. Firstly, the challenge they often face is the need to explain to people (mainly customers) that they are doing something new or different and the often need to rebrand their product or service. Secondly, seeking approval from investors, partners, or suppliers, is as important as assuring customers of changes, since pivots often lead to drastic changes and tech startups need the support of key stakeholders, such as investors, partners and suppliers. Thirdly, early-stage startups often have a relatively small team; one of the biggest challenges for entrepreneurs can be coping with the workload, training the team members, and recruiting more employees, which all have a big impact on the level of cash flow and the ability to pivot.

The following quotations provide representative illustrations on the challenges experienced by tech startups:

Participant 15 expressed the view that, *"The change in management. People's mindset is one of the things because they got used to it and any change, they do not like* [*sic*]*."*

Participant 17 said, *"Absolutely pivots are really hard. One of the first challenges is you have to explain to people (customers) that you are now doing something different.* [*sic*]*."*

Participant 18 said that their tech startup had faced the challenges of persuading the stakeholders, partners, or suppliers, and onboarding new resources, and the interviewee mentioned that *"For the customer segment pivot yes. So, the challenges around that were the team that we had on board and structure of the company had to change to match the change in segments. Then the customer need pivot yes, because it required a completely different discipline to be added. To the requirements of the team i.e., training. So, for customer need pivot we had to get new people and it was different* [*sic*]*."*

Participant 19's challenge was gaining acceptance of market and customers. The tech entrepreneur said that *"Getting some market traction and I have to survive; I would say that was the main issue* [*sic*]*."*

Participant 22 mentioned, *"I think the challenge is always how to listen with the minimal changes. So, you know, we all want to listen to our customers, but you automatically divide whatever they say into unrealistic, too expensive to do or let's try to think of an out-of-the-box solution* [*sic*]*."*

Participant 24 explained, *"Some challenges are other suppliers or partners were not able to accommodate the pivot that we were making therefore we had made much more drastic* *changes. Some of the pivots necessitated changes to technology or people or process that made them quite challenging to do. It took a little bit of time for some of the pivots for the rest of the company to get on board and understand why you were doing it* [*sic*]*."*

By Contrast, tech entrepreneurs who had small teams, did not find any major challenges to pursue pivots. For example, participant 18 said that pursuing a platform pivot did not create any challenges. Similarly, Participant 12 mentioned that *"No, because we are a small team, every pivot was a good decision* [*sic*]*."*

The six quotes above are examples of tech entrepreneurs who faced challenges, with their startups, due to pivoting. Furthermore, the study has provided examples of participants who encountered no challenges.

7.5 Discussion

The results of the qualitative data analysis of thirty tech entrepreneurs addressed the third research question i.e., impact of phases of technology entrepreneurship on pivoting. Fifty-seven percent of interviewees agreed with the above statement. However, thirty-four percent of the tech entrepreneurs did not accept the current framework of technology entrepreneurship proposed by Spigel and Matrix (2011).

They believe that the phases of technology entrepreneurship do not represent a straightforward linear process. Rather, it is much more complex and involves more phases than the existing framework. Therefore, the study will investigate further in the longitudinal interviews regarding the framework of technology entrepreneurship.

The research study evaluated the Lean Startup approach and the technology S-curve to understand how tech startups pivot and the role of technology maturity in the process. In this regard, the study extends the current knowledge base through explicitly examining the interconnection between the emergent concept of entrepreneurial pivoting and the more recognized theory of the technology s-curve. In the extant literature, researchers have previously tried to understand the lean principles through the lens of the S-curve theory. For example, a study by Negrao et al. (2019) focused on understanding lean manufacturing and business performance using the S-curve theory. Similarly, Overall and Wise (2015) used the S-curve model to understand customer development in a startup. Consequently, the study described herein extends this literature through using the technology S-curve model to understand the influence of technology maturity on pivoting, which is part of the lean startup approach. In addition, the empirical study identifies the importance of technology maturity (i.e., the stage of technology in the technology S-curve) for tech startups and its influence on pivoting. So, to answer the question as to whether technology maturity and the corresponding stage of the technology in the S-curve influence pivoting by tech startups? The qualitative data analysis has shown that 70% of the tech entrepreneurs agreed that the stages of technology in the technology S-curve impact pivoting and only 20% of the participants did not agree with this position. The research study has provided a breakdown of responses in relation to this question. For example, 80% of the tech entrepreneurs from the internet technology sector agreed that the stage of technology maturity influences pivoting, followed by 67% of the software technology sector.

While conducting interviews, tech entrepreneurs were asked whether pivoting leads to a change in technology used by the tech startup? After analysing twenty-eight responses, the study found that 43% of the tech entrepreneurs agreed that pivoting leads to technology change. However, 57% of the tech entrepreneurs did not agree, and therefore, no conclusive evidence could be identified to properly address the above question and ascertain whether pivoting leads to a change in the technology used by the startup.

The study also focused on understanding the most common stage in the technology S-curve where tech startups pursue a pivot? The tech entrepreneurs were asked at which stage in the technology S-curve did their startup pursue pivot(s), and 70% of the interviewees agreed that the level of technology maturity influences entrepreneurial pivoting. Based on the qualitative data analysis, it was identified that 62% of the tech startups prefer to pivot during the introduction stage of the technology, whereas the second most preferred stage in the technology S-curve to pivot is the growth stage (19%). The reason for pivoting in the earlier stages of the technology life cycle is that tech startups believe it is more cost-effective and efficient. Tech startups can still, of course, pivot in later stages. However, pivoting would likely be expensive because they would have invested heavily in the technology before it has reached the maturity or decline stage. This finding is consistent with the study by Taylor and Taylor (2012), which described how technology can be uncertain, and the preferences of potential users are often unclear. Therefore, a tech entrepreneur can be expected to encounter the need to pursue multiple pivots in the introduction stage of the technology S-curve.

In regard to practitioner implications of the study, tech entrepreneurs can use the findings to improve their understanding of which stage of the technology S-curve they can pursue pivot(s). The empirical results support the study of Byun et al. (2018), as 62% of the tech startups confirmed that pivoting in the earlier stages of the technology development cycle can be more cost-effective. Byun et al. (2018) explained that a tech entrepreneur needs to focus on leveraging R&D and thereby make strategic decisions about investment in the new technology during the initial stage of the technology life cycle. Later, the developed technology is released in the market, and the performance of the technology grows rapidly, thereby enabling development of a new industry-standard technology.

7.6 Conclusion

The chapter of the research study relates to understanding the influence of the phase of TE (i.e., formation, exploitation, and renewal) on pivoting. It was found that over half of the high-tech entrepreneurs (57%) believe that the phase of TE influences pivoting. However, ten high-tech entrepreneurs (34%) also felt that the existing linear process of formation, exploitation and renewal needed to capture TE's complexity and realities adequately. These high-tech entrepreneurs did not agree with the framework of technology entrepreneurship by Spiegel and Marxt (2011). Hence, they could not confirm the influence of the phase of TE on pivoting. The empirical study has shown that further research needs to be carried out to understand the different phases of TE and the complexities of a tech startup's journey.

One of objectives of the research study is focused on improving the understanding of how the concept of technology S-curve can be utilised to support the survivability of tech startups. The qualitative data analysis has shown that 70% of the tech entrepreneurs that were interviewed agreed that technology maturity (i.e., the stage of technology in the technology S-curve) influences pivoting. Moreover, tech entrepreneurs prefer to pivot during the earlier stages of the technology S-curve (i.e., at the introduction stage of technology) because it is less time consuming and more cost-effective. On the matter of whether pivoting leads to a change in the underlying technology for the tech startup, the findings show that 57% of the interviewees stated there was no change in the core technology after pivoting, while the remaining interviewees agreed with this position.

To understand further how the concepts of the LSA, technology entrepreneurship and the technology S-curve can be utilised to support the survivability of the tech startups, the research study conducted longitudinal interviews with nine tech entrepreneurs. The next chapter will be focused on providing the qualitative data analysis on the longitudinal interviews and discussion of the results.

Chapter 8: Results and discussion (Primary data: Longitudinal interviews)

8.1 Introduction

As mentioned in the previous chapters, the research study on entrepreneurial pivoting was conducted to understand the interconnection among the emergent concept of the 'Lean Startup Approach' with the more established concepts of 'Technology Entrepreneurship' and 'Technology S-curve'. In the previous results and discussion chapters (i.e., chapters 6 and 7), the research study validated the types of pivots and the factors that lead startups to pivot. The study has also established that the phases of technology entrepreneurship impact pivoting and the stage of technology in the technology S-curve influences pivoting.

The empirical results have identified that the existing framework for TE needs to be enhanced as it does not appear to capture the real-life experiences of tech entrepreneurs. Therefore, the study conducted longitudinal interviews in three phases. The first phase of interviews focused on understanding how the global pandemic COVID-19 impacted the business of tech entrepreneurs and whether the tech startups pivoted to address COVID-19. The second phase of interviews concentrated on establishing a deeper understanding of the TE framework and technology S-curve concepts and their impact or influence on pivoting. The final phase of longitudinal interviews focused on identifying whether the technology readiness level (TRL) for the startup's main technology influences pivoting and also whether the tech entrepreneurs become emotionally attached to their initial business and this results in pivoting being resisted.

8.2 The first phase of longitudinal interviews

8.2.1 Startups adjusting to the crisis

Several researchers, such as Hermann (1963), Fink (1986), Hills (1998), Dutton (1986), and Quarantelli (1988), defined a crisis as an extreme, unpredictable, or unexpected event that requires urgent attention from organisations. It is a challenge for startups/companies because it hinders operations and creates ambiguity in decision-making (cited in Doern et al., 2019). Furthermore, Williams et al. (2017) explained a crisis as being caused by a company's strategic changes or shallow probability events, such as natural disasters, that disrupt the organisation's normal functioning.

Doren (2016) conducted studies on the experience of small businesses during crises such as riots. The researcher highlighted the need for more empirical studies on crisis management in entrepreneurship. The study by Doern (2016) explained how small businesses were affected due to the 2011 London riots. The study identified that small business owners or entrepreneurs not only incurred material losses but also faced psychological or emotional costs. In addition, the study illustrated how a small business can become resilient and less vulnerable to crises by learning and adapting to previous experiences.

The effects of global crises due to recession, war, or pandemics frequently devastate markets, organisations, and individuals worldwide. The latest global crisis that the world faced is the COVID-19 pandemic. Since the beginning of 2020, the world health organisation (WHO) and governments worldwide have taken several measures to control the pandemic. One such measure was a complete lockdown that paralysed many industries. Various studies have been published on the effect of COVID-19 on businesses. For example, Sanasi and Ghezzi (2022) studied whether pivoting can strategically respond to a crisis. The study developed a comparative multiple-case study of four Italian firms to understand how they redesigned their strategies to respond to the COVID-19 crisis.

Similarly, Berends et al. (2021) and Hampel et al. (2020) explained that pivots could help firms change direction to manage the emergence of unanticipated circumstances. Another example is the study of Norris et al. (2021), where they explained how companies in the restaurant industry had to change their business models to stay in business, i.e., engaging in food collection and delivery services. Likewise, a study by Peterson and Scharber (2020) explained how schools in Minnesota, USA pivoted to remote learning with the help of technology integration. These studies indicate the importance of pivots for the organisation's survival.

Doern's (2021) study on the handling of the COVID-19 crisis by small businesses illustrated that business recovery was difficult during the early lockdown period, i.e., March 2020. The study's findings illustrated the experiences of entrepreneurs, such as how they handled the early stages of the crisis and developed tactical awareness. The study has also identified a new phase of crisis management, i.e., short-term recovery.

The first phase of the longitudinal interviews was conducted after the initial five months of lockdown in the UK i.e., from August to September 2020, and was designed to understand how tech startups are responding to the global crisis and whether they pursued pivots to address the challenges faced due to COVID-19. The nine participants were asked the same questions to understand how their tech startups handled the COVID-19 challenges. The questions focused on understanding whether they had pivoted during the lockdown. If they responded yes, they were also asked what the factor(s) and type were of pivots their startup adopted.

During the interviews, the study also collected other data, such as the phase of technology entrepreneurship in which their tech startup currently exists and whether the startup faced any new challenges, which were not illustrated in the initial thirty interviews. Furthermore, the study also collected further and more detailed information about the stage of the core technology in the technology S-curve.

In the first phase of longitudinal interviews, the participants were questioned whether they encountered any new challenge(s) due to the pandemic—table 26 displays the participants' responses. Five out of nine tech entrepreneurs mentioned that they did face new challenges due to the pandemic. However, only one tech entrepreneur i.e., participant 17, did pursue a customer need pivot because of change in market conditions due to the pandemic. The remaining four participants explained that either they had secured enough funding to run the business for the next one to two years or the tech startup had hands-on projects that they were not very concerned with the current market conditions due to the pandemic. The study asked the tech entrepreneurs who were facing challenges whether they were going to pivot. They responded that they were not very keen to bring changes to their business as the tech startups are secured either in terms of funding, projects, and resources, or all three.

Table 26. Participants viewpoints on challenges faced by their tech startups at the beginning of the pandemic.

Participant ID	New challenges faced due to the pandemic	Type of pivot pursued during this phase
Participant 2	Acquiring new customers was the challenge as the country was in lockdown, and tech entrepreneur could not conduct any face-to-face meetings with potential clients	No pivot pursued during the 1st phase of interviews
Participant 4	No new challenge faced by the tech startup	No pivot pursued during the 1st phase of interviews
Participant 9	No new challenge faced by the tech startup	No pivot pursued during the 1st phase of interviews
Participant 14	Financial crisis as government did not release the funds	No pivot pursued during the 1st phase of interviews
Participant 16	Tech startups B2B sales were down	No pivot pursued during the 1st phase of interviews
Participant 17	Market conditions that changed due to the pandemic	Customer need pivot
Participant 18	No new challenge faced by the tech startup	No pivot pursued during the 1st phase of interviews
Participant 26	Assigning and monitoring the work remotely was the challenge	No pivot pursued during the 1st phase of interviews
Participant 29	No new challenge faced by the tech startup	No pivot pursued during the 1st phase of interviews

During the 1st phase of longitudinal interviews, the participants were asked to rate their startup's performance on a Likert scale of one to five with one being the lowest and five being the highest. Apart from participants 16, 18, 26 and 29, five agreed that their tech startups performance improved during and after lockdown due to COVID-19. Participant 18 rated the startup's performance as two after the lockdown and mentioned that it had nothing to do with

COVID-19 but because of a change in focus on the business. Table 27 illustrates the participants' responses on their tech startup performance before and after the lockdown. The following are quotes explaining the performance of the startup.

Participant 18 mentioned, "*In business growth, so immediately before lockdown we did pretty well. We just landed a chunk of funding and had a ten percent increase in our customer base. I'd say probably around three. During lockdown our focus has been less on the commercial side of the business because we have money in the bank. It has been more about getting us to the point where we can deliver a service. So commercially probably not that great. Probably about two, but that is not because of the lockdown that is because of where we are and our focus with business at the moment is not around or has not been around building our customer base* [*sic*]."

Participant 2 explained, "*I think we have done very well. So, I will give it sort of four. So, we made huge commercial advancements actually just deciding and now we need to go big essentially expand setting up new teams, new channel partners. So, I am pretty good considering it. I think lockdown was just the Catalyst. It was a trigger point now we need to really; you know, I think the worst one just furlough or going part-time backing up the worst choice and thankfully we did not lay off anyone* [*sic*]*.*"

Similarly, participant 9 shared that *"We have actually been doing pretty well during lockdown. So, I would say we are probably four. So just to give you a feel for what happened and then you understand so before the lockdown period we obviously developing the technology and we were delivering these training courses and to help fund the tech. Just before lockdown we applied to a to join a tech accelerator in our region. During lockdown we have started on the tech accelerator. So, we have been accepted onto it after some stiff competition, which is actually been helping us and despite lockdown. the other thing that is been really key is as a* *result of the pandemic Innovate UK put out for some short-term Innovation funding for companies, which we were also successful in winning. So, we won an Innovate UK grant for a short-term project which was for us really significant, and we are right in the middle of this now. So again, if we did not have that pandemic, we would not have had that grant funding and that is accelerated what we are doing with, you know, grown our team and everything* [*sic*].*"*

By contrast, participant 26, whose tech startup performance was downgraded from three to two, explained that *"In the last 12 months we made some progress in terms of engaging with potential customers and also got our first sort of paid for proof-of-concept study and then during the lockdown the labs were closed, and we could not physically do all that much. So, most of the things had to go on hold* [*sic*].*"*

Table 27. Participants response on their tech startups performance before and after the lockdown.

Participant ID	Performance rating before lockdown	Performance rating after lockdown	Reason
Participant 2	3	4	Commercial advancement.
Participant 4	2	4	Startup has automated the process, leading to less requirement of workforce.
Participant 9	3	4	Joined tech accelerator programme and received grants from Innovate UK due to pandemic.
Participant 14	2	4	Their product went live at the time of lockdown.
Participant 16	3	2	B2B sales went down.
Participant 17	3	4	Because of COVID-19 the business growth accelerated.
Participant 18	3	2	COVID-19 did not impact the business. The tech startup's focus changed with respect to their business.
Participant 26	3	2	Remote working was not possible for the startup.

			Therefore, operations got hold.
Participant 29	4	1	Impact on the sales was drastic.

The study also collected data about the startup's position according to the phases of TE and the stage of core technology according to the technology S-curve. Table 28 illustrates the responses.

Table 28. Participants response on their tech startup's position on TE and technology S-curve during lockdown.

Participant ID	**TE phase**	**Stage of technology in the technology S-curve**
Participant 2	Renewal phase	Growth stage
Participant 4	Renewal phase	Introduction stage
Participant 9	Exploitation phase	Introduction stage
Participant 14	Renewal phase	Growth stage
Participant 16	Formation phase	Growth stage
Participant 17	Formation phase	Growth stage
Participant 18	Did not recognise the TE framework	Growth stage
Participant 26	Formation phase	Growth stage
Participant 29	Exploitation phase	Growth stage

8.3 The second phase of longitudinal interviews

After establishing that the phases of technology entrepreneurship influence pivoting and the stages of technology in technology S-curve impact pivoting from the empirical results of primary thirty interviews, the research study conducted a second phase of longitudinal interviews. The intent behind the second phase of longitudinal interviews was to further evaluate the concepts of LSA, TE and technology S-curve and understand what category of pivots (i.e., product-level, market-level, strategy-level, and team-level pivots) can be pursued at a particular TE phase or stage of technology in the technology S-curve. Apart from the abovementioned objective, the study also focused on understanding the tech entrepreneurs' point of view on pivoting and whether different types of pivots can be categorised based on the domino effect.

8.3.1 Tech entrepreneurs' definition of pivoting

At the beginning of the data collection process, the interviewer used definitions of the types of pivots and factors that trigger pivoting defined in the published sources (Ries, 2011; Bajwa et al., 2017; Sood and Tellis, 2005 and Spiegel and Martxt, 2011) so that each participant could fully appreciate the concept of entrepreneurial pivoting during the interviews. However, to understand the viewpoint of tech entrepreneurs, in the second phase of the longitudinal interviews, participants were asked to define the pivot in general. In addition, they were asked to explain the driving factor behind pursuing pivot(s) and what is their primary goal behind pursuing pivots. Even though all nine participants defined a pivot in their own words the central idea behind those definitions was same i.e., change in direction without changing the values or goals.

The interviewer asked the following questions to understand the interviewees' viewpoints on pivoting:

Q1. Explain what is pivoting.

Q2. What is your primary goal as a tech entrepreneur while considering pivoting?

a) To achieve business growth

b) To enhance the quality of the product or service

c) To improve customer engagement

d) Other

To see all the questions asked in longitudinal interviews see Appendix VII.

The participants tended to define a pivot as a change in the path of the startup to reach the destination without changing the values or goals of the tech startup. For example, several tech entrepreneurs explained that they initiated the startup(s) with a plan. During their entrepreneurial journey, they pivoted as they identified an improved opportunity partly due to a more reasonable understanding of market requirements. Several tech entrepreneurs mentioned that when a startup cannot sell its product/service because customers do not want to use it, they either have to shut down the business or develop the technology and pursue a new path. In order to survive, they adopt pivot(s), which can be viewed as the driving factor behind a tech startup to pivot. The following are selected quotes from participants:

Participant 2 mentioned, *"While moving from one opportunity to another, it is essential to pivot for the startup's survival* [*sic*]*."*

Whereas participant 5 shared that according to him/her, *"Pivoting means doing something different so that other things can fall in place* [*sic*]*."*

Similarly, participant 17 explained pivoting as a change in strategic direction: *"Pivoting is changing strategic direction based on external factor* [*sic*]*."*

The viewpoint of participant 14 on pivoting is: "*It is basically choices where you have to go forward, I think. In my point of view pivoting is not a choice. It is a choice between survival and death in ways of your idea because if you do not make the change then you are not going to be able to continue on the trajectory you wish to have. Therefore, you have to take the steps and those steps will sometime be difficult, but it is not a choice basically* [*sic*]."

According to Participant 26, pivoting can be divided into areas, namely choosing the market and the business model: "*Well, I guess changing course of direction or for us it has mainly meant which industry we focus on but also in terms of thinking about which business model* *that we want to use. So, these were sort of two areas that we have been thinking about in terms of pivoting* [*sic*].*"*

During the interviews, the participants were asked to explain their purpose behind pivoting. While three participants (3, 16, and 26) said that business growth is their sole purpose behind pivoting, participant 4 explained enhancement of a product or service quality as the goal of their tech startup to pivot. However, participant 16 said enhancing the product or service quality and improving customer engagement are primary reasons for the startup to pivot. By Contrast, participants 17 and 18 said all options are interlinked. Whereas Participant 14 mentioned that pivoting is not a choice and according to the interviewee, their startup did not consider any of the above options.

Upon analysing all nine interview transcripts, the study found that three prospects are equally crucial to a tech startup, i.e., business growth; enhancement of product or service quality; and customer engagement. One of these three aspects becomes more significant depending on the tech startup's position in the TE phases.

For example, participant 16 said, *"Primary goal for an early-stage businesses is obviously a market fit product* [*sic*].*"* Furthermore, participant 4 said, similar to participant 16, *"I guess it is about surviving that infant mortality phase. Initial phase of a startup a lot of them die because they realise their product is not market fit* [*sic*]." In both examples, participants 4 and 16 were referring to the formation phase in TE when they mentioned early-stage startups or the infant mortality phase. Another example is participant 18, *"It could be anyone of them, depending upon the situation* [*sic*].*"*

8.3.2 Types of pivots that can be pursued at a given phase of TE

Since the initial phase of interviews identified 57% of the tech entrepreneurs agreed that the phases of technology entrepreneurship influence pivoting, the second phase of longitudinal interviews was conducted to understand which type of pivots can be pursued at a specific phase of TE. As a result, the interviewer asked participants their viewpoints on the matter and to classify pivots according to the phase of technology entrepreneurship. Based on the participants' experience, different types of pivots were classified under formation, exploitation, and renewal phases. Table 29 illustrates the responses of the interviewees.

Table 29. Pivots pursed at a particular phase of technology entrepreneurship according to the viewpoints of participants.

Participant ID	**Formation phase**	**Exploitation phase**	**Renewal phase**
Participant-4	Technology pivot	Zoom-in pivot	
	Customer segment pivot	Side project pivot	
	Customer need pivot	Value capture pivot	
	Channel pivot		
Participant-9	Zoom-in pivot	Zoom-out pivot	Zoom-in pivot
	Complete pivot	Platform pivot	Zoom-out pivot
		Customer segment pivot	platform pivot
		Market segment pivot	Customer need pivot
		Side project pivot	Channel pivot
			Market segment pivot
			Value capture pivot
Participant-2	Technology pivot	Zoom-in pivot	Zoom-in pivot
	Market segment pivot	Technology pivot	Customer segment pivot
	Complete pivot	Customer segment pivot	Value capture pivot
	Side project pivot	Market segment pivot	Engine of growth pivot
	Social pivot	Engine of growth pivot	Social pivot
		Business architecture pivot	
		Social pivot	
Participant-14	Zoom-in pivot	Zoom-in pivot	Zoom-in pivot
	Zoom-out pivot	Zoom-out pivot	Zoom-out pivot
	Technology pivot	Technology pivot	Technology pivot
	Platform pivot	Platform pivot	Platform pivot
	Social pivot	Market segment pivot	Engine of growth pivot
			Value capture pivot

Participant-17	Technology pivot	Value capture pivot	Customer segment pivot
	Platform pivot	Business architecture pivot	Customer need pivot
	Side project pivot	Engine of growth pivot	Market segment pivot
	Complete pivot	Side project pivot	Channel pivot
	Social pivot	Complete pivot	Side project pivot
		Social pivot	Complete pivot
			Social pivot
Participant-18	Customer segment pivot	Zoom-in pivot	Side project pivot
	Customer need pivot	Zoom-out pivot	Complete pivot
	Channel pivot	Platform pivot	Social pivot
	Market segment pivot	Side project pivot	Zoom-in pivot
	Value capture pivot	Complete pivot	Zoom-out pivot
	Customer segment pivot	Social pivot	Technology pivot
	Side project pivot		Business architecture pivot
	Complete pivot		
	Social pivot		
Participant-29	Complete pivot	Zoom-in pivot	Channel pivot
	Customer need pivot	Zoom-out pivot	Market segment pivot
	Customer segment pivot	Technology pivot	Side project pivot
	Technology pivot	Platform pivot	
		Business architecture pivot	
Participant-26	Technology pivot	Zoom-in pivot	Customer segment pivot
		Zoom-out pivot	Customer need pivot
		Platform pivot	Market segment pivot
		Customer segment pivot	Channel pivot
		Customer need pivot	Business architecture pivot
		Market segment pivot	
		Channel pivot	
		Business architecture pivot	
Participant-16	Technology pivot	Zoom-in pivot	Customer segment pivot
	Side project pivot	Zoom-out pivot	Customer need pivot
	Complete pivot	Technology pivot	Channel pivot

		Platform pivot	Market segment pivot
			Value capture pivot
			Engine of growth pivot
			Business architecture pivot
			Social pivot

The nine interviewees shared their experiences of pivoting and grouped different types of pivots in each phase of technology entrepreneurship. For example, participant 9 mentioned, "*Formation phase: I would say number one (zoom-in pivot) and number 12 (complete pivot). Exploitation phase: I think two (zoom-out pivot), four (platform pivot), five (customer segment pivot), eight (market segment) and thirteen (side project pivot). Renewal phase: Number one (zoom-in pivot), number two (zoom-out pivot), number four (platform pivot), number six (customer need pivot), number seven (channel pivot), number eight (market segment pivot) and number nine (value capture pivot) I think these are all valid at that stage* [*sic*]."

Similarly, participant 17 stated: "*Technology related pivots happen in the beginning. Renewal phase is customers, so customer segment pivot, Customer need pivot, Channel pivot and Market segment pivot that is the renewal phase because you got the customers, you are learning from them.* Formation phase you might do a technology pivot because you are trying to build, and it is not working and platform pivot [*sic*]."

Another example is from participant 26, who explained that *"The Technology pivot probably comes very early on and because that is the first thing you build is technology. Then I guess in the second phase things like these Zoom-in and Zoom-out pivots can happen quite easily if we realise that you are actually offering more than is needed or where we need to offer more than we're currently offering. Maybe also the Platform pivot. And then for the other one sort of like Market segment and Customer segment pivots and channel pivot those are things that I think quite easily can be done at the end or like when you grow the business maybe and that is time passes so maybe you know 10 years in you need different channels* [*sic*]."

When the qualitative data was analysed, the empirical evidence showed that the technology pivot is the most pursued pivot in the formation phase. The second most pursued pivot is the complete pivot, followed by the side project and social pivot. In the case of the exploitation phase the most pursued pivot is the zoom-in pivot. The second most pursued pivot in the exploitation phase is zoom-out and platform pivot followed by the technology pivot, market segment pivot, business architecture pivot, side project and social pivot. For the final phase of TE i.e., the renewal phase, the most pursued pivots are the channel and market segment pivots. The second most pursued pivots in the renewal phase are the zoom-in pivot, customer segment and customer need pivot, value capture pivot and social pivot. Table 30 illustrates the summary of each pivot pursued at a particular phase of technology entrepreneurship according to participants perspective.

Table 30. Summary of number of times a pivot pursued at a particular phase of TE according to viewpoints of participants.

Pivot category	**Type of pivot**	**Formation phase**	**Exploitation phase**	**Renewal phase**
Product level pivot	Zoom-in pivot	2	7	4
Product level pivot	Zoom-out pivot	1	6	3
Product level pivot	Platform pivot	2	6	2
Product level pivot	Technology pivot	7	4	2
Market level pivot	Customer segment pivot	3	3	4
Market level pivot	Customer need pivot	3	1	4
Market level pivot	Channel pivot	3	1	5
Market level pivot	Market segment pivot	2	4	5
Strategy level pivot	Value capture pivot	1	2	4
Strategy level pivot	Engine of growth pivot	0	2	3
Strategy level pivot	Business architecture pivot	0	4	3

Strategy level pivot	Complete pivot	6	2	2
Strategy level pivot	Side project pivot	4	4	3
Team level pivot	Social pivot	4	4	4

Figure 47 is the bar chart illustration explaining the number of times a product-level, market-level, strategy level and team-level types of pivots are pursued in the three phases of technology entrepreneurship. The data analysis has further revealed that product-level pivots are most pursued in technology entrepreneurship's formation and exploitation phases. By Contrast, the market-level pivots are most pursued in the renewal phase. Finally, strategy-level pivots are the second most pursued in the exploitation and renewal phases.

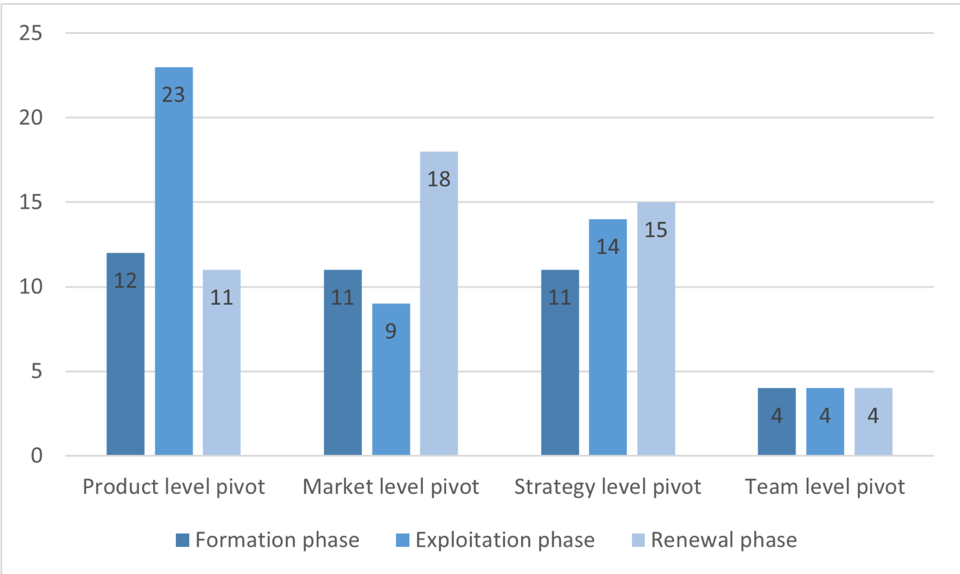

Figure 47. Classification of pivots based to the phase of technology entrepreneurship according to viewpoints of participants.

8.3.3 Pivots pursued at a particular stage of technology in the technology S-curve

A further aspect of the study was to determine if the stages of the technology S-curve influence pivoting. The first thirty primary interviews revealed that 70% of the tech entrepreneurs agreed that technology maturity influences pivoting. Therefore, in the second phase of longitudinal interviews, the participants were asked to classify pivots that can be pursued at a particular stage of the technology S-curve based on their experience. Table 31 illustrates the details of the types of pivots for each stage of the technology S-curve.

For example, participant 4 explained, *"Technological pivot will come in introduction, growth stage and maturity phase. Customer segment and customer need pivot will come in growth and maturity stage. Banks likes to use a lot of mature tech but also, they would not mind using the tech that is growing taking little bit of risk but mainly they want mature technology and that will influence some of the pivots we are having. I do not think channel pivot will matter here, same thing for market segment pivot. It is down to the customers and technology to be honest. These are the only pivots that I can think of affecting the technology, others I do not see them really being affected by the technology we are using* [*sic*]*."*

Likewise, participant 2 mentioned, "*looking at our case probably I think number nine (value capture pivot) because of new underlining technology we can capture more value commercially. So, nine (value capture pivot) and ten (engine of growth pivot) create more value in growth stage* [*sic*]."

Moreover, participant 26 said, "*I think during the introduction stage the Zoom-in and Zoom-out pivots to figure out and the customer need pivot. In the second stage the engine of growth. Well, you can also do the value capture pivot. In the third stage I think the possibly a Market segment pivot or also Customer segment pivot can help if there is market or customer segments where there would be more growth than the ones that was currently focused on and may be able also Side project pivot if it turns out that there is a certain side business that are actually growing faster than the main business. And in the final the complete pivot might be useful also the maybe did Platform or Technology pivot if that would improve the situation* [*sic*]."

Table 31. Pivots pursued at a particular stage of technology in the technology S-curve according to the viewpoints of participants.

Participant-ID	Introduction stage	Growth stage	Maturity stage	Decline stage
Participant-4	Technology pivot	Technology pivot	Technology pivot	Technology pivot
		Customer segment pivot	Customer segment pivot	
		Customer need pivot	Customer need pivot	
Participant-9	Zoom-in pivot	Zoom-in pivot	Technology pivot	Technology pivot
	Technology pivot	Zoom-out pivot	Channel pivot	Business architecture pivot
	Complete pivot	Platform pivot	Market segment pivot	Complete pivot
		Customer segment pivot	Value capture pivot	Side project pivot
		Customer need pivot	Business architecture pivot	
		Value capture pivot		
		Engine of growth pivot		
		Business architecture pivot		
		Side project pivot		
Participant-2		Value capture pivot		
		Business architecture pivot		
Participant-14	TLC does not influence pivoting			
Particiapnt-17	Technology pivot	Technology pivot	Value capture pivot	Customer segment pivot
	Platform pivot	Platform pivot	Business architecture pivot	Customer need pivot
	Side project pivot	Side project pivot	Engine of growth pivot	Market segment pivot
	Complete pivot	Complete pivot	Side project pivot	Channel pivot
	Social pivot	Social pivot	Complete pivot	Side project pivot
			Social pivot	Complete pivot

Participant-18	TLC does not influence pivoting			
Participant-29	Participant said that their CTO takes decisions related to technology			
Participant-26	Zoom-in pivot	Engine of growth pivot	Market segment pivot	Complete pivot
	Zoom-out pivot	Value capture pivot	Customer segment pivot	Platform pivot
	Customer need pivot		Side project pivot	Technology pivot
Participant-16	TLC does not influence pivoting			

By Contrast, participant 29 explained that the CTO of their startup takes decisions related to the technology aspect. Therefore, the interviewee could not provide any answer. Whereas participant 18 explained that technology maturity does not influence pivoting. According to the participant, *"Technology does not equal innovation. In fact, technology quite often gets in the way of innovation. The reality is that Product-Market fit and experience drive innovation* [*sic*]*."*

Similarly, participant 16 mentioned, "*Most of your pivots is they are related to your product and your customer's needs. You would rather adopt a technology to those needs. So, technology is following customer needs right. If you have a demand for new features which is related with new technologies, so yes, you will have to change your technology, but if you do not have this requirement, so you would probably not do it. This is same about maturity of the technology. So, if you see that your technology is performing the same way as it was performing and your customers happy with that, but you do not see the growth anymore, but you are just happy with business with the current revenues and the current service you provide to do your customers then you wouldn't have any pivots. So, you will just follow the demand of your customers. So, it's not really what is dictated by technology. So, customer requirements are what initially dictate your pivots* [*sic*]."

When the qualitative data was analysed, the empirical evidence showed that in the opinion of the participants the technology pivot is the most pursued pivot in the introduction stage. The second most pursued pivots are the zoom-in and complete pivot. In the case of the growth stage the most pursued pivot is the value capture pivot. The next most pursued pivots are the technology pivot, platform pivot, customer segment pivot, customer need pivot, engine of growth pivot, business architecture pivot and the side project pivot. In the third stage (maturity stage), the technology pivot, customer segment pivot, market segment pivot, value capture pivot, business architecture pivot and side project pivot are the most pursued. For the final stage i.e., the decline stage, the most pursued pivot is the technology pivot. Table 32 summaries the number of times a pivot is pursued at a particular stage of technology S-curve according to the opinions and experience of the tech entrepreneurs.

Table 32. Summary of the number of times a pivot is pursued at a particular stage technology S-curve according to the experience of the participants.

Pivot level	Type of pivot	Introduction stage	Growth stage	Maturity stage	Decline stage
Product level pivot	Zoom-in pivot	2	1	0	0
Product level pivot	Zoom-out pivot	1	1	0	0
Product level pivot	Platform pivot	1	2	0	1
Product level pivot	Technology pivot	3	2	2	3
Market level pivot	Customer segment pivot	0	2	2	1
Market level pivot	Customer need pivot	1	2	1	1
Market level pivot	Channel pivot	0	0	1	1
Market level pivot	Market segment pivot	0	0	2	1
Strategy level pivot	Value capture pivot	0	4	2	0

Strategy level pivot	Engine of growth pivot	0	2	1	0
Strategy level pivot	Business architecture pivot	0	2	2	1
Strategy level pivot	Complete pivot	2	1	1	1
Strategy level pivot	Side project pivot	1	2	2	2
Team level pivot	Social pivot	1	1	1	0

Figure 48 is the bar chart illustration showing the number of times a product-level, market-level, strategy level and team-level pivots are pursued in the four stages of the technology S-curve. The data analysis has further revealed that product-level pivots are most pursued in the introduction stage of the technology S-curve according to participant opinions. By Contrast, the strategy-level pivots are most pursued in the growth and maturity stages, and market-level pivots are the second most pursued in these stages. Finally, in the decline stage a tech startup can pursue any pivot from product, market, and strategy-level pivots.

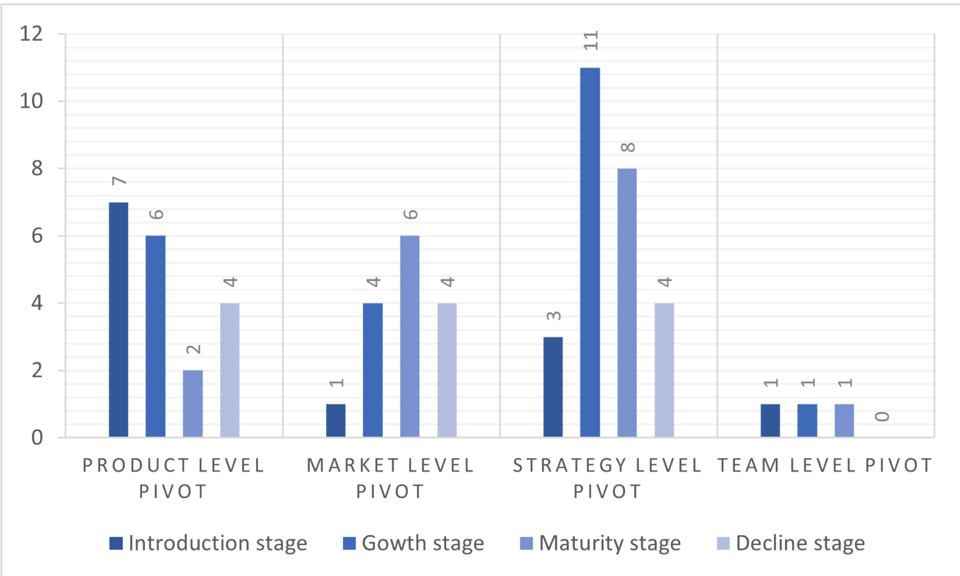

Figure 48. Classification of pivots for each stage of technology S-curve.

8.3.4 Domino effect in pivoting

The qualitative data analysis of the primary thirty interviews revealed a domino effect in pivoting i.e., a single pivot can lead to multiple pivots. Figure 46 from Chapter 7 illustrates the pivots pursued by the tech entrepreneurs who participated in the primary thirty interviews and their experience of the domino effect of pivoting. Therefore, to understand this phenomenon further, during the second-round longitudinal interviews, the interviewees were asked to group the pivots that led to a domino effect. Table 33 lists the classification of pivots based on the domino effect according to the viewpoints of the tech entrepreneurs.

Table 33. Classification of pivots based on domino effect according to viewpoint of tech entrepreneurs.

Participant-ID	**Domino effect**				
	Pivot-1	**Pivot-2**	**Pivot-3**	**Pivot-4**	**Pivot-5**
Participant-4	Market segment pivot	Customer need pivot	Channel pivot		
	Zoom-in pivot	Value capture pivot	Side project pivot		
Participant-9	Did not experience domino effect				
Participant-2	Technology pivot	Market segment pivot			
Participant-14	Did not experience domino effect				
Participant-17	Technology pivot	Zoom-out pivot	Customer need pivot		
	Customer need pivot	Technology pivot			
	Customer segment pivot	Zoom-in pivot	Zoom-out pivot	Technology pivot	Platform pivot
	Customer need pivot	Zoom-in pivot	Zoom-out pivot	Technology pivot	Platform pivot
	Market segment pivot	Zoom-in pivot	Zoom-out pivot	Technology pivot	Platform pivot
	Value capture pivot	Zoom-in pivot	Zoom-out pivot	Technology pivot	Platform pivot
	Engine of growth pivot	Zoom-in pivot	Zoom-out pivot	Technology pivot	Platform pivot
Participant-18	Did not experience domino effect				
Participant-29	Did not experience domino effect				
Participant-26	Business architecture pivot	Customer segment pivot			

	Value capture pivot	Zoom-in pivot	Zoom-out pivot	Channel pivot	
	Customer need pivot	Market segment pivot			
Participant-16	Zoom-in pivot	Side project pivot	Platform pivot		
	Technology pivot	Zoom-in pivot	Side project pivot		
	Zoom-out pivot	complete pivot	Engine of growth pivot		
	Customer need pivot	Zoom-in pivot	Zoom-out pivot	Technology pivot	
	Customer segment pivot	Channel pivot	Market segment pivot	Value capture pivot	Social pivot

The tech entrepreneurs shared their viewpoints on classifying the pivots based on the domino effect. Out of nine interviewees, participants 16, 18 and 29 never experienced a domino effect while pivoting. Therefore, they could not classify the pivots. However, the remaining interviewees did categorise pivots based on their past experiences. For example, participant 4 shared two instances, i.e., if a tech startup first pursues a market segment pivot, that may lead to pursuing a customer need pivot, followed by a channel pivot. In the second instance, if a tech startup first pursues a zoom-in pivot, it may lead to a value capture pivot, followed by a side project pivot.

Similarly, participant 17 has provided seven examples of categorising pivots based on the domino effect. The first one is that pursuing a technology pivot could lead to a zoom-out pivot, and a customer need pivot due to the domino effect. If a tech entrepreneur adopts a customer need pivot, that may lead his/her startup to pursue a technology pivot. In the remaining five instances, the interviewee mentioned that if a startup first pursues a customer segment or a customer need or a market segment or a value capture, or the engine of growth pivot, that could result in first pursuing zoom-in followed by a zoom-out, technology and a platform pivot in that order.

8.4 Third phase of longitudinal interviews

The purpose of the third phase of longitudinal interviews is to address the following:

a) To understand the impact of pivoting on the tech startup's performance.

b) To understand whether tech entrepreneurs face emotional attachment towards their initial ideas i.e., psychological ownership.

c) To assess whether the stages of technology readiness level (TRL) for the company's technology influence pivoting.

8.4.1 Impact of pivoting on the tech startup's performance

The performance of a startup company can be measured by its financial and non-financial performance. In financial terms, one can consider profit, turnover and equity owned by shareholders, such as venture capitalists. Whereas non-financial performance includes parameters such as number of employees and customer relationships. The participants were asked to explain the impact of pivoting on their startup's performance. All participants (100%; N=9) agreed that pivoting positively impacted their tech startup. For example, participant 4 said, "*Yeah, positive impact because we started having people buying the product for the first time* [*sic*]."

Although participants 14 and 29 agreed that pivoting had a positive impact in the long term, they faced a negative impact in the short term. For example, participant 14 explained, "*Financially negative and from performance, it was positive because it allowed me to run the course the way I wanted to [sic]*."

8.4.2 Influence of TRL levels on pivoting

In the third phase of longitudinal interviews, the participants were asked to evaluate their startup technologies based on the TRL scale of one to nine. The TRL framework has been utilised in various industries to measure technology development from the idea generation stage to the commercialisation stage. TRL-1 is basic principles observed and reported, and TRL-9 is an actual system "flight proven" through successful mission operations (Straub, 2015). Based on the qualitative data analysis, 56% of the participants (N=5) agreed that the stage of TRL influences pivoting. However, participants 2, 26 and 16 disagreed, and participant 29 was unsure whether stages of TRL influence pivoting. Most of the tech startup's underlying technology are in between TRL-6 to TRL-9, which means they have successfully tested it or that technology is readily available in the market. Table 34 represents the responses of participants on whether TRL levels influence pivoting.

Table 34. Participant responses on whether TRL levels influence pivoting.

Participant-ID	**TRL stage**	**Influence of TRL (yes/no/not sure)**
Participant-2	TRL-6	No
Participant-4	TRL-9	Yes
Participant-9	TRL-8	Yes
Participant-14	TRL-9	Yes
Participant-16	TRL-9	No
Particiapnt-17	TRL-9	Yes
Participant-18	TRL-7	Yes
Participant-26	TRL-6	No
Participant-29	TRL-9	Not sure

The following are selected quotes from the participants who agreed that the levels in TRL influence pivoting. Participant-9 mentioned, "*Yeah. I think it does actually. I think partly because the further into the higher up you are and the more proven it is also the more time and money you have spent on it. So, you are kind of going to try and keep using it, I think [sic].*"

Likewise, participant 18 said "*I think it does. If you are talking about technical pivoting. When you are looking to find out whether a technology specific technology is usable, you will find that out in TRL-4 or TRL-5 most of the time. And you won't necessarily find out whether or not it's cost-effective until TRL-7* [*sic*]."

Participant 29, who was unsure, said, "*I have to say I am not sure because, we have only ever used the sort of very proven technologies* [*sic*]."

Interestingly, participant 16 commented that pivoting influences TRL and not vice versa. The participant commented, "*I think you cannot get to the level 9 and pivot. You put probably already pivoted before level 9, because it's means if you have get to the level 9 so you already have a market fit and sales and operations. There could be correlation, but it's rather pivoting is influencing the Technology Readiness Level than Technology Readiness Level is influencing the pivoting* [*sic*]."

8.4.3 Psychological ownership towards initial business idea

Crilly (2018), Felix et al. (2018) and Grimes (2018) mentioned that entrepreneurs can face psychological ownership issues i.e., individuals identify themselves with their ideas. Although this has the benefit of having increased commitment towards the idea, it may also lead to disregarding the idea of pivoting when required. Therefore, in the third phase of the longitudinal interviews, the tech entrepreneurs were asked whether they faced any emotional attachment toward their initial idea and also resisted the idea of pivoting. At the same time, they were requested to explain their leadership style out of six leadership styles namely transformational, transactional, charismatic, democratic, autocratic, and bureaucratic leadership styles explained in the literature review chapter. The purpose of asking questions related to emotional attachment and leadership style was to identify if there is any empirical relationship between these two parameters. Table 35 provides the nine participants' responses on their leadership style and whether they felt any emotional attachment towards initial ideas.

Table 35. Participants responses on psychological ownership.

Participant-ID	**Leadership style**	**Emotionally attachment towards the initial idea**
Participant-2	Democratic leadership	Yes
Participant-4	Transformational leadership	No
Participant-9	Transactional leadership	Yes
Participant-14	Transactional leadership	No
Participant-16	Charismatic leadership	No
Participant-17	Transactional leadership	Yes
Participant-18	Charismatic leadership	Yes

Participant-26	Transformational leadership	Yes
Participant-29	Charismatic leadership	Yes

The empirical findings suggested that 67% (N=6) of the participants were emotionally attached to their initial idea and potentially shown a degree of resistance towards pivoting even though in the end they did indeed pivot. In contrast, only 33% (N=3) of participants were open to pivoting since the beginning of their entrepreneurial journey.

For example, participant 2 mentioned, "*I guess mostly attached to the ideas yes, but at the same time, you know that realizing some of these ideas are just not going to work I guess so, yes, it's attachment but would have preparedness to sort of change focus when he was obviously was not working out. So yeah, it's attached up until certain point and then a breakout* [*sic*]."

Similarly, participant 17 said, "*Yeah, absolutely yeah right at the beginning. So, I think we mentioned that when we talked about it. The very first pivot I hung on to it for probably two years when I probably knew within about six months, and I needed to pivot but I tried to persuade the world that I was right rather listening to the world and pivoting* [*sic*]."

In addition, participant 18 explained, "*I think every time you pivot, you have to get over an emotional attachment to the original idea* [*sic*]."

By Contrast, participant 4 responded, "*I would not say we were emotionally attached. I would say we were considering is this the right time and when is the right time to pivot?* [*sic*]."

Likewise, participant 16 explained, "*Pivoting is all about evolution of your business, so it is a very bad sign if you are stay attached to the initial vision and kind of stubborn not reacting to customer needs* [*sic*]."

Before asking whether the tech entrepreneurs felt emotionally connected to the original strategy of their startup, the interviewer asked them to explain the leadership style they followed. Interestingly, few tech entrepreneurs mentioned they followed multiple leadership styles. For example, participant 4 said transformational and democratic leadership styles. Similarly, participant 14 mentioned transactional, democratic, and charismatic leadership styles. However, when asked main leadership style followed by participant 4, interviewee said transformational and participant 14 mentioned transactional leadership style. Table 35 lists the leadership styles followed by the participants.

8.4.4 Factors and pivots pursued by interviewees during longitudinal interviews

In all three phases of longitudinal interviews, interviewees were asked whether they faced any new challenges due to the pandemic and did they pivot to address those challenges. Table 36 shows the responses of the participants in all three phases of the interviews. Out of nine tech entrepreneurs, only two opted for pivots to address the challenges caused due to pandemic. Participant 4 pursued a complete pivot due to technology challenges, competition, wrong timing and the influence of investor, promoter, or founder. By contrast, participant, 17 performed three pivots. This tech entrepreneur pursued customer need pivot due to market conditions during the first phase of longitudinal interviews. The other two pivots were the customer need pivot and the technology pivot for business expansion during the second phase of pivots.

Table 36. Participant responses from all three phases of longitudinal interviews on pivoting.

Participant ID	New challenge(s) during 1st phase of interviews	Type of pivot pursued	New challenge(s) during 2nd phase of interviews	Type of pivot pursued	New challenge(s) during 3rd phase of interviews	Type of pivot pursued
Participant 2	Acquiring new customers	Not pursued	No new challenges	Not pursued	Revenue was not growing	Not pursued
Participant 4	No new challenge	Not pursued	Technology challenges	Not pursued	Technology challenges, competition, wrong timing and influence of investor,	A complete pivot

					promoter, or founder	
Participant 9	No new challenge	Not pursued	Customer retention and team motivation	Not pursued	Business financial	Not pursued
Participant 14	Financial crisis, payment from govt. not received	Not pursued	Financial crisis, payment from govt. not received	Not pursued	Financial crisis, payment from govt. not received	Not pursued
Participant 16	B2B sales were down	Not pursued	No new challenge	Not pursued	No new challenge	Not pursued
Participant 17	Market conditions	Customer need pivot	Business expansion	Customer need pivot & technology pivot	Talent acquisition	Not pursued
Participant 18	No new challenge	Not pursued	No new challenge	Not pursued	No new challenge	Not pursued
Participant 26	Working remotely	Not pursued	Geopolitical issues	Not pursued	Geopolitical issues	Zoom-in pivot
Participant 29	No new challenge	Not pursued	No new challenge	Not pursued	No new challenge	Not pursued

8.5 Discussion

The results from the qualitative data analysis of twenty-seven longitudinal interviews conducted in three phases provided insights into the following:

a) How tech startups have addressed the uncertainty due to the pandemic.

b) Understanding the types of pivots that were classified according to TE phases and technology stages in the technology S-curve based on the viewpoints of tech entrepreneurs

b) Classification of pivots based on the domino effect according to the viewpoints of tech entrepreneurs.

c) Improved understanding of the impact of pivots on tech startup's performance.

d) Whether tech entrepreneurs' display psychological ownership towards the initial business idea

e) Whether the levels of TRL influence pivoting.

In the first phase of the longitudinal interviews, the study investigated how the performance of the tech startups was impacted due to the pandemic. Five out of nine tech entrepreneurs mentioned that their startup's performance improved over the lockdown. At the same time, the study collected information on the phase of startup according to the TE framework. Interestingly, the performance of startups in either the exploitation or renewal phase improved after the lockdown due to the pandemic. Participants 16 and 26, whose startups were in the formation phase, mentioned that their performance had decreased due to the pandemic. Only two tech entrepreneurs pursued pivots, whereas the rest continued with the same business models.

The primary thirty interview results indicated that 57% of the tech entrepreneurs believed that the phases of TE influence pivoting. The second phase of longitudinal interviews focused on understanding whether pivots can be classified based on the phases of TE. The nine participants from the longitudinal interviews presented their viewpoints on classifying different types of pivots, as shown in Table 31. For example, participant 2 explained that the technology pivot, market segment pivot, complete pivot, side project pivot and social pivot are the most suitable types of pivots to pursue during the formation phase of technology entrepreneurship. Whereas zoom-in, customer segment, market segment, engine of growth, business architecture and technology pivot could be pursued in the exploitation phase. In the final phase of TE, the most suitable pivots are the social, value capture, engine of growth, customer segment pivot, and zoom-in pivots.

The study identified that product-level pivots are most suitable to adopt when the startup is in TE's formation and exploitation phase. Similarly, market-level pivots are most suitable to adopt when the startup is in the renewal phase of TE. Strategy-level pivots are the second-most preferred pivots in all three phases of technology entrepreneurship. Furthermore, the qualitative data analysis helped the study to determine which pivots from each pivot level category are most pursued by tech startups. For example, zoom-in and technology pivots are the most pursued from the product-level pivot category. Similarly, from the market-level pivot category, customer and market segment pivots are most pursued. Regarding strategy-level pivots, complete and side project pivots are the most pursued pivots by tech startups.

The primary thirty interview results indicated that 70% of the tech entrepreneurs believed that the stages of technology in the technology S-curve impact pivoting. The second phase of longitudinal interviews focused on understanding whether pivots can be classified based on the stages of technology in the technology S-curve. The nine participants from the longitudinal interviews presented their viewpoints on classifying different types of pivots, as shown in Table 32. For example, participant 26 explained that zoom-in, zoom-out and customer-need pivots are the most suitable types of pivots to pursue during the introduction stage of the technology S-curve. In the growth stage of the technology S-curve, the engine of growth and value capture pivot could be the most suitable. In the third stage of the technology S-curve, the most suitable pivots are the market segment, customer segment and side project pivots. For the final stage of the technology S-curve i.e., the decline stage, complete, platform and technology pivots are the most suitable pivots to pursue.

The study identified that product-level pivots are most pursued when the core technology of a tech startup is in the introduction stage. By Contrast, strategy-level pivots are most favoured to be pursued in the growth stage of the technology S-curve. However, the market-level and team-level pivots are not the first preference in all the four stages of the technology S-curve.

Furthermore, the qualitative data analysis helped the study to identify which pivots from each pivot level category are most pursued by tech startups. For example, technology and platform pivots are the most pursued from the product-level pivot category. Similarly, customer-segment and customer-need pivots are most pursued from the market-level pivot category. Regarding strategy-level pivots, value capture and side project pivots are the most pursued pivots by tech startups.

The empirical results from the primary thirty interviews established that there is a domino effect in pivoting, which confirms the study by Terho et al. (2015). The second phase of longitudinal interviews helped the research study to further understand the domino effect in pivoting in more detail. Table 33 describes the pivots that can lead a tech startup to pursue another pivot(s). Five out of nine participants have clustered different types of pivots under the domino effect. The study has provided additional knowledge on the domino effect of pivoting, which is based on the personal experience of tech entrepreneurs. The interviewees presented their viewpoints on categorising pivots based on the domino effect. Even though the study could not establish a definitive answer as to which pivot would lead to another pivot, it has provided further supporting evidence that there is a domino effect in pivoting and supported the empirical findings of the primary thirty interviews. This confirms the previous studies on this by Terho et al. (2015).

The qualitative data analysis of the primary thirty interviews established that pivoting helps create and sustain value propositions. To understand this in more detail, in the third phase of longitudinal interviews, the interviewer asked the participants how pivoting has impacted the tech startup's performance. The results have indicated that the tech entrepreneurs agreed that pivoting positively impacted the performance of tech startups. The study focused on ascertaining whether pivoting positively impacted the financial or non-financial performance of tech startups. Therefore, in the third phase of longitudinal interviews, the interviewer explained financial and non-financial performance to each participant and then asked them to explain how pivoting has positively impacted the tech startup's performance. The participants answered that pivoting positively impacted tech startups' performance.

The empirical results from the primary thirty interviews provided evidence that the stage of technology in the technology S-curve impacts pivoting, as seventy percent of the tech entrepreneurs agreed. However, the research study sought to identify if the technology is yet to be commercialised and is in development. Does that developing technology still impact pivoting? Therefore, in the third phase of longitudinal interviews, the research study asked the participants whether the stage of technology according to the technology readiness level (TRL) impacts pivoting. Fifty-six percent of the tech entrepreneurs (N=5) accepted that the TRL stage of technology impacts pivoting. According to the TRL, the core technology used by all nine participants was between levels 6 to 9. This means that the tech startup's core technology was at least at the testing stage or ready to be commercialised.

Earlier studies on the TRL concept were applied in thermochemical splitting cycles, nuclear power plants, defence, oil, and gas industries (Boretti, 2021; Olechowski et al., 2015). However, very few studies on using the TRL framework in pivoting or entrepreneurship studies exist. This research study is one of the initial studies that has conducted qualitative research to compare the technology readiness level framework and pivoting.

Researchers such as Crilly (2018) Felix et al. (2018) and Grimes (2018) explained in their research that entrepreneurs may encounter psychological ownership problems because they (entrepreneurs) identify themselves with their ideas. Therefore, in the context of entrepreneurial pivoting, they may not choose to pivot or delay the decision. Both possibilities are not suitable for a startup. Through the longitudinal interviews, the research study has investigated this matter. Participants were asked whether they were emotionally connected to their initial idea(s). The study also wanted to identify if there is any correlation between leadership styles and psychological ownership issues towards the initial idea for a tech entrepreneur.

Sixty-seven percent of the interviewees (N=6) agreed they had psychological ownership issues early in their tech entrepreneurship careers. They were emotionally attached to their initial ideas and showed resistance towards pivoting. Therefore, the study's findings agree with the research of Crilly (2018), Felix et al. (2018) and Grimes (2018). At the same time, the study also analysed the data to understand which leadership style has displayed resistance towards pivoting from the initial idea. Again, sixty-seven per cent of the participants (N=4) followed either transactional or charismatic leadership styles, and they displayed the most resistance towards pivoting. Hence, the research study found empirical evidence to support Crilly’s (2018) and Grimes’s (2018) study and highlighted that tech entrepreneurs who follow transactional or charismatic leadership styles mostly resist pivoting in the early stage of their tech startups.

8.6 Conclusion

This chapter explains the results and discussion of twenty-seven interviews conducted longitudinally over a total period of ten months. In this chapter, the study has presented the viewpoints of tech entrepreneurs on classifying the pivots based on the phases of technology entrepreneurship, stages of technology in the technology S-curve and the domino effect. In the case of the TE phases, product-level pivots are most pursued when a tech startup is in the exploitation phase. By contrast, market-level pivots are most favoured to pursue in the renewal phase of technology entrepreneurship; strategy-level pivots are equally favourable in TE’s exploitation and renewal phases.

Similarly, for the technology S-curve, product-level pivots are most pursued when the core technology of a tech startup is in the introduction stage. Whereas strategy-level pivots are most favoured to pursue in the growth stage of the technology S-curve. However, the market-level and team-level pivots are not the first preference in all the four stages of the technology S-curve. The study has also classified different types of pivots based on the domino effect. Table 33 explains the different types of pivots grouped under the domino effect. Unfortunately, the study could not establish concrete evidence of which pivot would lead to another pivot. However, it has found further supporting evidence that there is a domino effect in pivoting and supported the empirical findings of the primary thirty interviews as well as confirmed the study by Terho et al. (2015) that first identified the domino effect in pivoting. By contrast, the longitudinal interviews found supporting evidence that pivoting has a positive impact on tech startups' performance over the long term. Additionally, the study provided evidence that the TRL stages impact pivoting.

The longitudinal interview results agree with Crilly's (2018), Grimes's (2018) and Felix et al. (2018) study on psychological ownership issues concerning initial business idea(s). Furthermore, the study identified that tech entrepreneurs who follow transactional and charismatic leadership styles resisted more towards pivoting due to psychological ownership issues towards their idea(s). In the following chapter, the study will address the seven research questions defined in Chapter 3 and provide conclusion, limitations of the study and future work to the research study.

Chapter 9: Conclusions

9.1 Introduction

This chapter aims to address the research questions and concludes the thesis. In the previous chapters 5, 6, 7 and 8 (i.e., results and discussion of secondary data, thirty primary interviews and longitudinal interviews), all the empirical findings through a qualitative analysis were presented. In this chapter, using the empirical findings, the study will address the research questions (RQs) detailed in Chapter 3 and how they are connected to the previous research studies cited in the literature review. In addition, this chapter will present the significance of the findings and how it is relevant to the field of entrepreneurship. The study will conclude this thesis by providing the limitations of this study and future work for the research study conclusion of this thesis.

The qualitative research study has conducted fifty-seven interviews to understand how high-tech entrepreneurs successfully pivot their tech startups as part of the entrepreneurial journey. The empirical results validated different types of pivots and the factors that lead to pivoting, as well as identifying new pivots and factors, thereby expanding the overall set of pivots and factors that cause pivots. The study has established that the phases of technology entrepreneurship influence pivoting. In addition, the qualitative analysis demonstrated that the stages of technology in the technology S-curve impact pivoting. Furthermore, the study has confirmed and validated the domino effect in pivoting; the challenges a tech startup faces while implementing pivots; and determined the influence of the technology readiness level (TRL) on pivoting. The qualitative data analysis confirmed that tech entrepreneurs encounter psychological ownership towards their initial business idea, which leads to the potential to resist the idea of pivoting.

The seven research questions that were defined in chapter four are as follows:

RQ-1. How can a tech startup change its direction through pivoting?

RQ-2. What are the factors that cause a tech startup to change direction and pivot?

RQ-3. Does the phase of technology entrepreneurship influence pivoting?

RQ-4: Does the corresponding stage of the technology in the technology S-curve influence pivoting by tech startups?

RQ-5: Does the TRL of the startup's primary technology influence pivoting by the startup?

RQ-6: Does a tech entrepreneur face psychological ownership issues while pivoting?

RQ-7: Can a tech startup create and sustain its value proposition through pivoting?

The following sections in this chapter will address the seven research questions sequentially while summarising the thesis.

9.2 RQ-1. How can a tech startup change its direction through pivoting?

The first research question is about understanding how the tech startup changes its direction through pivoting. Ries (2011) explained that high-tech entrepreneurs may face certain challenges and pivot from the original strategy to address them—the concept of pivoting led to a new approach to research on entrepreneurship. Pivoting implies selecting a new path for creating value. Studying entrepreneurial pivoting involves understanding different types of pivots pursued by tech startups. Therefore, the qualitative analysis has revealed new insights into the characteristics of pivots and the rationale behind pivoting as a core strategy to underpin startup long-term survivability.

The empirical results have validated fourteen different types of pivots identified through a literature review of the work of Ries (2011), Bajwa et al. (2017) and Hirvikoski (2014). In addition, the study has identified two new pivots, namely, the 'business ecosystem pivot' and ‘brand pivot’, which are classified as strategic-level pivots. Thus, the study determined that sixteen pivots characterise the process of entrepreneurial pivoting. In order to validate existing pivots and identify new ones, the research study has collected primary and secondary data. The secondary data laid the path for gathering primary data through interviews, since analysing the secondary data helped the study draft the interview questions and understand how the concept of pivoting described outside of academic literature. Furthermore, secondary data was deemed necessary for the research study since more examples of startups or companies that pursued pivots needed to be identified.

Table 3 in Chapter 4 (Methodology) represents the initial evaluation of pivoting and the factors that cause pivoting collected through secondary data. The study reviewed articles by Ries (2011), Bajwa et al. (2017), Comberg et al. (2014) and Terho et al. (2015). Apart from these academic journals, several internet pages such as Basulto (2015); BusinessNewsWales (2020); ChannelSight (2020); Glaveski (2018); Gebel (2019); Hinchliffe (2020); Kumar (2020); Morgan (2020); Nazar (2013); O’Hear and Lomas (2014); Pruitt (2017); Ringle (2017); Superscript (2020) and Woodford (2020) were studied to understand the factors that triggered the pivot and the corresponding adopted pivot to address that factor. According to secondary data analysis, the customer segment, customer need, and value capture pivots are the most pursued types of pivots.

Empirical analysis of the primary thirty interviews (i.e., the initial thirty interviews) in the research study validated the existing types of pivots mentioned in the literature—Table 7 from the Chapter 6 illustrates the types of pivots the interviewees. The customer segment pivot was the most frequent pivot pursued by tech entrepreneurs and the side project pivot was the second most frequent. As defined in the literature review, pivots are organised into four categories i.e., product level, market level, strategy level and team level pivots. Under the product-level category, the technology pivot was the most pursued pivot. Similarly, the customer segment pivot was the most frequent for the market-level category. In the strategy-level category, the side project pivot was pursued the most. The final category is the team-level pivot, and under this category, there is only one pivot, i.e., the social pivot, and it is one of the least pursued pivots overall.

9.3. RQ-2 What are the factors that cause a tech startup to change direction and pivot?

As explained earlier, the goal behind studying eighty tech startups or companies collected through secondary data is to secure an initial understanding of pivoting and its associated factors—Table 3 in the methodology chapter illustrates different types of pivots and the factors that triggered those pivots. As explained in the literature review, factors are organised into two types i.e., external, and internal factors. The secondary data analysis revealed that the 'flawed business model' (N=30, 16%) was the most frequent factor that initiated a pivot by the tech startups/companies. The second most frequent factor that was faced by the tech startups/companies was 'customer feedback' (N=27, 14%). According to the secondary data analysis, the most frequent factors are the 'flawed business model', 'customer feedback', and 'technology challenges'.

The qualitative data analysis of the thirty primary interviews validated the factors that trigger a pivot(s) mentioned in the literature review chapter. Table 7 from Chapter 6 illustrates the factors that caused the interviewees' startup to pursue a pivot(s). In addition, the empirical analysis has identified the factors and their frequency. For example, the most frequent factor was 'customer feedback' (N=43). The second most frequent factor was 'competition' (N=32). The empirical findings identified two new factors i.e., 'strategic longevity' and 'geopolitical issues'. These two new factors are classified under the external factors category. Additionally, table 24 from Chapter 6 describes the most pursued pivot categories against each factor.

9.4 RQ-3 Does the phase of technology entrepreneurship influence pivoting?

Technology entrepreneurship is a prominent theory in the entrepreneurship literature. For example, Schumpeter (1942) explained that entrepreneurs develop market-fit products by exploring new combinations of resources. Similarly, Beckman et al. (2012a) mentioned that TE is a convergence of entrepreneurial opportunities and technological innovation. Spiegel and Marxt (2011) defined TE in three phases: Formation, Exploitation and Renewal. In the first phase, the tech entrepreneur will assemble the resources and technical systems to recognise the opportunities or ideas. Once an opportunity is recognised, the tech entrepreneur will explore the idea with the help of resources and technical systems. This is the second phase in TE. The third and final phase of TE involves improvising a product or service to adapt to customer demands or feedback.

In order to understand whether the phases of TE influence pivoting, the research study interviewed tech entrepreneurs. The data analysis of the primary thirty interviews identified that 57% (seventeen participants) agreed that the phases of technology entrepreneurship influence pivoting. 30% (nine participants) believed that TE phases do not influence pivoting, and 13% (four participants) were unsure whether TE phases influence pivoting.

Once it was established that the phases of technology entrepreneurship influence pivoting, the purpose of conducting longitudinal interviews was to gain a deeper level of insight and knowledge of pivoting concerning technology entrepreneurship and various other aspects, such as understanding whether different types of pivots can be classified according to the phase of entrepreneurship and developing a new conceptual framework of TE. Accordingly, the research study has conducted interviews to collect data on what types of pivots are pursued at a particular phase of TE. Table 29 from Chapter 8 illustrates the type of pivot pursued at a particular phase of technology entrepreneurship.

The qualitative data analysis of the longitudinal interviews identified that the technology pivot (78%) was the most frequently opted pivot during the formation phase. The two most frequently opted pivots are complete (67%) and side-project pivots (44%) after the technology pivot in the formation phase. During the second phase of TE i.e., the exploitation phase, zoom-in pivot (78%) was the most frequently pursued. It was followed by zoom-out and platform pivot (67%). In the final phase (renewal) of the TE channel and market segment pivots (56%) are the most frequently adopted. The data analysis has further revealed that product-level pivots are the most frequently applied category of pivots in the formation and exploitation phases of TE. In comparison, the market-level pivots are the most commonly pursued category of pivots during the renewal phase of TE. At the same time, strategy-level pivots are the second most common category used during TE's exploitation and renewal phases.

The empirical findings of thirty primary interviews found that thirty-four percent of tech entrepreneurs did not recognise the existing framework of TE by Spiegel and Marxt (2011). They pointed out that the phases of TE are not a linear process. Instead, they considered TE phases as circular processes with feedback loops. Therefore, through the analysis of the longitudinal interviews, the study has developed a new conceptual framework for technology entrepreneurship. The new framework has three stages, like Spiegel and Marxt (2011). However, the framework has a feedback loop and two new phases within the final stage of TE—Figure 49 depicts the new conceptual framework for technology entrepreneurship.

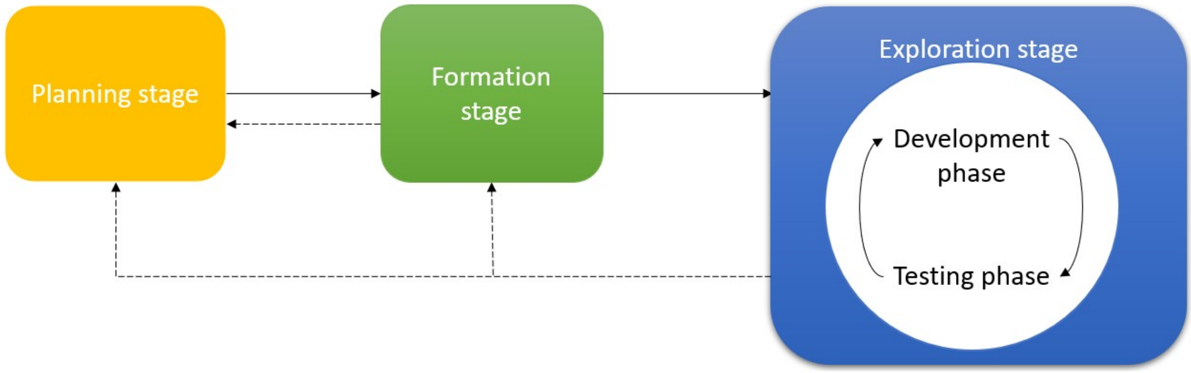

Figure 49. Proposed technology entrepreneurship framework.

The first stage of technology entrepreneurship is called the 'planning stage'. In this phase, a tech entrepreneur conducts market research to understand the customer's requirements and examine new opportunities and ideas. The 'formation stage' follows the planning phase. Once the opportunity or an idea is identified, the tech entrepreneur assembles the resources and other technical aspects to develop strategies for addressing the customer requirements and commercialising the opportunity.

The third stage in technology entrepreneurship is known as the 'exploration stage', which consists of two phases. The first is the development phase, where the tech entrepreneur develops a minimum viable product (MVP) with the help of existing resources based on preliminary market research. Once the MVP is developed, the tech startup moves to the testing phase, where they enter the market and iteratively seek to improve the product/service with the help of customer feedback. However, this entire process is not linear. Instead, there are feedback loops giving rise to the prospect of circularity i.e., due to pivoting at any phase of technology entrepreneurship, the tech startup may return to the previous phase and start the process again. The new conceptual framework integrates the findings of the empirical study and the experiences of the tech entrepreneurs with the theories of TE and LSA, and thereby provides a new approach that can be utilised by those involved in launching and developing tech startup companies.

9.5 RQ-4 Does the corresponding stage of the technology in the technology S-curve influence pivoting by tech startups?

The roots of the technology S-curve are derived from the eighteenth century. Kucharavy and De Guio (2011) mentioned that in the 1960s, the S-curve model was used to comprehend technological forecasting. It has four stages: introduction, growth, maturity, and decline. Sood and Tellis (2005) have explained each stage in their research study. They explained the introduction stage as the first stage in the technology S-curve, where the technology will gradually progress in terms of performance. The second stage is the growth stage, where the technology's performance rapidly progresses. The maturity stage follows this stage. In the maturity stage, the progress of technology performance moves slowly or reaches the upper limit. The final stage in the technology S-curve is the decline stage. Marjot and Lu (2008) explained that the value of technology declines as new technology replaces it and slowly the old technology becomes obsolete.

The research study has conducted qualitative data analysis on thirty primary interviews to understand whether the stages of technology in the technology S-curve impact pivoting. It was found that seventy percent of the interviewees agreed that technology maturity impacts pivoting. Therefore, the study has addressed the research question that the corresponding stage of technology in the technology S-curve influence pivoting by tech startups. In addition, the empirical results identified that sixty-two percent of tech entrepreneurs preferred to pivot when their core technology was in the introduction stage since it was the most cost-effective. This finding has supported the study of Byun et al. (2018) that a tech entrepreneur needs to focus on leveraging R&D and thereby make strategic decisions about investment in the new technology during the initial stage of the technology life cycle.

The study used the opportunity of longitudinal interviews to understand whether pivots can be classified according to the stage of technology in the technology S-curve. The empirical evidence indicated that, in the participants' opinion, the technology pivot was the most frequently pursued pivot when the core technology of the tech startup was in the introduction stage. The zoom-in and complete pivot are the second most often pursued pivots during the introduction stage. By contrast, when the core technology of the tech startup is in the growth stage, the value capture pivot is the most frequently pursued. The next most often pursued pivots are the technology pivot, platform pivot, customer segment pivot, customer need pivot, engine of growth pivot, business architecture pivot and side project pivot. However, overall strategic-level pivots are the most adopted pivots in the growth stage of the technology S-curve.

In the maturity stage of the technology S-curve, six pivots, namely: the technology pivot, customer segment pivot, market segment pivot, value capture pivot, business architecture pivot and side project pivot, are the most frequently pursued. Out of these six pivots, most of them are from strategy-level pivots. In the final stage of the technology S-curve i.e., the decline stage, the most pursued pivot is the technology pivot. The longitudinal interviews established that the technology pivot is the most pursued in all four stages of the technology S-curve. Alternatively, the strategy-level category pivots are often preferred to pursue by tech entrepreneurs when their tech startup's core technology is in either growth or maturity stage.

9.6 RQ-5: Does the TRL of the startup's primary technology influence pivoting by the startup?

The Technology Readiness Level scale has nine levels, and the framework is employed by various industries to estimate technology development from idea generation to commercialisation. Rybicka et al. (2016) explained that the nine levels can be organised into three groups. TRL 1 to 3 can be defined as a lab scale; TRL 4 to 6 can be described as pilot scales; and TRL levels 7 to 9 can be called commercial scales.

After determining the stages of technology in the technology S-curve impact pivoting, the study focused on enhancing further the understanding of the impact of technology on pivoting, which is still in the developing stage. The reason was that many tech startups adopt or develop new technology that is yet to be commercialised. Since the technology S-curve examines the life cycle of technology after it is commercialised, the study selected the TRL framework. The TRL framework discusses the technology development, from the basic principles stage to the commercialisation stage.

Through longitudinal interviews, the study has collected responses from tech entrepreneurs to understand whether the stages of TRL influence pivoting. The qualitative data analysis indicated that fifty-six percent of the interviewees agreed that the stages of TRL influence pivoting. The study evaluated the stages of the core technology of tech startups and identified that all the participants' core technology lies between TRL levels 6 to 9. This means all the core technologies were pilot or commercial and completed lab levels. The tech entrepreneurs explained that technology-related pivoting can be pursued when the core technology is TRL 4 or 5. Pivoting at the higher levels of TRL may cost more for tech startups. Relevant quotes to support the statement were illustrated in Chapter 8, sub-section 8.4.3. This finding is similar to the findings of the impact of technology maturity on pivoting, where the participants explained that they prefer to pivot at the introduction stage of the technology S-curve. The study has identified empirical evidence to address the research question on the influence of TRL stages on pivoting. The study established that, yes, the stage of TRL influences pivoting.

9.7 RQ-6: Does a tech entrepreneur face psychological ownership issues while pivoting?

Studies by Felix et al. (2018), Grimes (2018) and Crilly (2018) highlighted that entrepreneurs could display a bias towards their initial business idea(s) due to psychological ownership. Therefore, the study gathered information through longitudinal interviews to understand whether tech entrepreneurs face psychological ownership issues and whether this can impact pivoting. This may lead to hampering the decision-making skills of the entrepreneurs. Research studies by McMullen and Shepard (2006), Bendana and Mandelbaum (2021), and Haynie et al. (2012) explain that decision-making is one of the focal points of entrepreneurial action. In the literature review chapter, the study described six different leadership styles i.e., transactional, transformational, charismatic, democratic, autocratic, and bureaucratic leadership styles.

In order to determine whether tech entrepreneurs face psychological ownership towards their initial business idea, the study collected qualitative data through longitudinal interviews. During the interviews, the tech entrepreneurs were questioned to choose which leadership style they follow, along with a follow-up question on whether they felt any resistance while pivoting during the initial stages of their entrepreneurial journey. The empirical evidence found that sixty-seven percent of the interviewees agreed that they were emotionally attached to their initial business idea and resisted the idea of pivoting. The qualitative data analysis has further revealed that most participants who agreed about having psychological ownership towards a business idea follow charismatic or transformational leadership styles. Therefore, the study has addressed the research question by providing evidence that tech entrepreneurs encounter emotional attachment towards their initial business idea and potentially show some form of resistance to the idea of pivoting.

9.8 RQ-7: Can a tech startup create and sustain its value proposition through pivoting?

The success of tech startups depends on many elements, including creating and sustaining the venture's value proposition. Guo et al. (2021), Kirchberger et al. (2020) and Wouters et al. (2018) explained the value proposition as the value that a firm intends to offer to its customers, which in turn explains why customers will prefer one company's product or service. Through the thirty primary interviews, the study confirmed that eighty percent of tech entrepreneurs agreed that pivoting helps create and sustain value proposition(s). The remaining twenty percent of the tech entrepreneurs did not deny that pivoting helps create a value proposition. Through the longitudinal interviews, the study collected data to understand how pivoting impacts the performance of startups. All the participants involved in the longitudinal interviews confirmed that pivoting positively impacted their tech startups' performance. This supports the above statement that a tech startup can create and sustain a value proposition.

9.9 Implications for practitioners (i.e., tech entrepreneurs) and policymakers

The study gives rise to several implications for practitioners (i.e., tech entrepreneurs), which are as follows:

1. Entrepreneurial pivoting is a value-adding process and a vital part of the LSA, where a startup can potentially pursue 16 types of pivots caused by 14 different factors.
2. Pivots help in creating and sustaining the value proposition. Therefore, a high-tech entrepreneur must be careful not to become overly emotionally connected to their original idea, which may inhibit the decision to pivot. Instead, they can be prepared to test new hypotheses in order to achieve the desired results after pivoting.
3. The empirical study has confirmed the domino effect in pivoting, which means one pivot can often lead to multiple pivots. For example, if a tech startup changes its customer segment, it may need to change its channel to reach the new customer segment.
4. There are three challenges that tech startups often face while attempting pivots: persuading customers; pursuing stakeholders, partners, or investors; and onboarding resources. Entrepreneurs can be cognisant of such challenges when pivoting.
5. Tech entrepreneurs should be aware of the benefits of startup pivoting in the introduction stage of the technology S-curve. This is because pivoting at a later stage in the S-curve can be more costly due to the greater level of committed resources and

well-established processes associated with the production of more mature products and services.

6. In the case where tech entrepreneurs decide to pivot, they should consider if there is a corresponding impact on the core technology of the company and whether the technology will need to be changed or modified in some way. It is recognized that such a technology change will also be contingent on the specific circumstances of the startup.
7. Tech entrepreneurs can use the technology S-curve to identify and communicate the stage of technology maturity for the core technology of the startup. This approach will help in securing financial support from investors and venture capitalists due to emphasising the growth potential of technology-based products and services as they progress through the S-curve model.
8. The technology S-curve indicates the performance of the core technology of the startup through identifying its stage of development. Therefore, tech entrepreneurs can periodically use the technology S-curve to evaluate the development stage of technology and thereafter consider whether or not to pursue a pivot in the context of the corresponding level of technology maturity.

This research study has given rise to a number of implications for policy makers engaged in the provision of guidance on how tech entrepreneurs can be supported. This is because the study has provided a richer picture of entrepreneurial pivoting and the impact of technology through capturing the insights of experienced tech entrepreneurs. This enhanced understanding seeks to build on the high level of adoption of the lean startup approach in the practitioner community through providing an empirical basis to the LSA as well as an appropriate linkage to management and technology strategy aspects (Contigiani and Levinthal, 2019). In terms of the support mechanisms that are provided to tech entrepreneurs, this includes access to investor networks (such as those involving venture capital and angel investors), mentoring and training, which may be accessible through being associated with an accelerator program (Metcalf et al., 2020), startup incubator (Pattnaik et al., 2020) or in the case of academic spin-offs from a university technology transfer office (Hamilton and Philbin, 2020). Consequently, the following recommendations are provided for policy makers:

1. Organisations involved in providing support and training to tech startups (such as tech transfer officers, accelerators, and government-backed initiatives) can benefit from the improved understanding of the types of pivots and factors that cause pivots developed by this study, which can be incorporated into the knowledge base and training provision of such organisations.
2. Mentors, coaches, advisors as well as non-executive directors who all provide some form of support and advice provision for tech startups are able to incorporate the evidence-based findings of this study into their support frameworks so that the survivability of tech startups in enhanced.
3. The financial investment community for startups, such as venture capitalists and angel investors, are able to consider the impact of entrepreneurial pivoting on the investment proposition, i.e., considering when to invest in the context of whether or not the startup has pivoted, or is just about to pivot.
4. Events and conferences organised towards improving our understanding of technology entrepreneurship may seek to increase the level of focus on empirical studies related to entrepreneurial pivoting as well as the other aspects of the LSA, such as the MVP and BML.
5. Since it has been found that technology maturity influences entrepreneurial pivoting, it is suggested that training programs for tech entrepreneurs also include information and advice on use of the technology s-curve so that entrepreneurs can understand where the startup's primary technology lies on the curve.

6. Mentors, coaches, and others involved in supporting tech entrepreneurs can benefit from gaining an improved understanding of the technology S-curve. This will help improve the quality of advice that can be provided to tech entrepreneurs on the impact of technology on entrepreneurial pivoting to ensure the survivability of startups.
7. Financial support and investment capital provided to tech startups can be structured in order to recognize the maturity of the startup's primary technology so that appropriate experimentation and development of the MVP can be adequately funded and resourced.
8. Support mechanisms provided to tech entrepreneurs should be available at the pre-launch as well as early launch stages of the company since it has been found that tech startups are most likely to pivot in the introduction stage of the technology in the s curve. Consequently, tech entrepreneurs can benefit from an improved awareness of this matter at this early stage, so they are prepared to pivot, when necessary, from the outset of the startup development process.
9. As there is a trend towards support being provided virtually to entrepreneurs, this should also include information, training, and advice on how technology maturity can influence entrepreneurial pivoting to ensure startup survivability.

9.10 Contribution to knowledge

The study's contribution to the literature on entrepreneurial pivoting is as follows:

1. The Lean Startup Approach is a topical phenomenon. Indeed, an article called Pivot decisions in startups: a systematic literature review by Flechas Chaparro et al. (2021) highlighted the need for more empirical research. Ries (2011) and Bajwa et al. (2017) are the prominent authors who discussed the types of pivots. The work of Bajwa et al. (2017) was based on secondary data analysis. However, this research study is one of the first in the literature on LSA that has collected primary source data, and the study has also validated and identified the different types of pivots and factors.

2. The research study is the first to compare three different theories and explain the pivoting experience of high-tech entrepreneurs. The study not only provided empirical evidence that the phases of TE influence pivoting but also classified the pivots according to phases of TE and developed a new conceptual framework for TE. The new conceptual framework has a feedback loop and the three new stages are called planning, formation, and exploration stage. The exploration stage consists of two phases known as the development and testing phases.
3. The research study examined entrepreneurial pivoting through the lens of the technology S-curve and technology readiness levels. The empirical evidence shows that the stages of technology maturity in the technology S-curve influence pivoting. The study also identified that the introduction stage is the most preferred stage to pivot for a tech startup. Similarly, in the case of TRL, tech entrepreneurs prefer to pivot at low levels of TRL.
4. The research study is one of the few studies that has provided evidence to substantiate and validate the emerging phenomenon of the domino effect in pivoting, where one pivot leads to further pivot(s). The empirical evidence illustrated the pivots that triggered other pivot(s) based on the experience of tech entrepreneurs. Furthermore, the study classified pivots based on the domino effect.
5. The qualitative research study established that tech startups achieved the desired results after pivoting. In addition, the study identified three significant challenges the tech startups face while pivoting, i.e., persuading customers; pursuing stakeholders, partners or suppliers; and onboarding resources.

9.11 Conclusion

9.11.1 Entrepreneurial pivoting

In the era of continuous innovation and digitalisation, a high-tech entrepreneur explores opportunities by harnessing technological innovation and the required resources to create and sustain a value proposition. During their entrepreneurial journey, high-tech entrepreneurs may face a challenge that leads to a pivot from the original strategy (Ries, 2011). Pivoting means selecting a new path for creating value. The concept of entrepreneurial pivoting leads to a new direction of research on entrepreneurship; it involves understanding the types of pivots and factors that trigger the pivot in an entrepreneurial journey. Simultaneously, this research opens the door to compare different entrepreneurship theories and systematise the corresponding knowledge. Pivots are categorised into four levels product, market, strategy, and team level. The research study validated all the existing 14 types of pivots from the literature review and identified two new pivots, namely 'business ecosystem pivot' and 'brand pivot', thereby resulting in a total of 16 types of pivots that are available to high-tech entrepreneurs. The study validated the 11 factors from the literature that trigger pivoting and identified three new factors that give rise to pivoting, namely 'geopolitical issues', 'substituted by a new entrant' and 'strategic longevity' thereby resulting in a total of 14 factors that cause pivoting.

9.11.2 Influence of TE phases on pivoting

The empirical results showed that fifty-seven percent of the tech entrepreneurs believed that the phases of technology entrepreneurship influence pivoting. Therefore, partial support was found for the research question of whether the phase of technology entrepreneurship influences the process of pivoting. Additionally, through the longitudinal interviews, the study has explained the viewpoints of tech entrepreneurs on categorising pivots based on phases of technology entrepreneurship. For example, product-level pivots are most pursued when a tech startup is in the exploitation phase. Similarly, when a tech startup is in the renewal phase, the most pursued pivots are from the market-level category.

By Contrast, the study found that thirty-four percent of tech entrepreneurs did not agree with the framework of technology entrepreneurship by Spiegel and Marxt (2011). Therefore, through longitudinal interviews, the study collected information on the phases of TE and proposed a new conceptual framework that integrates the findings of the study with the TE and LSA theories (see Figure 49). The new stages in TE are the planning, formation, and exploration stages, which are cyclically interlinked with each other and not linear. Additionally, the exploration stage has two phases, the development and testing phases.

9.11.3 Role of technology in pivoting

The research study aims to understand whether tech startups consider technology maturity while pivoting. Therefore, the study has considered the technology S-curve and technology readiness level frameworks and the intersection with entrepreneurial pivoting. The technology S-curve helps in understanding the life cycle of technology, which has been commercialised. By Contrast, TRL details the status of technology development in nine levels before it is commercialised.

9.11.3.1 Impact of stages of technology in the technology S-curve on pivoting

The empirical study was based on interviews with thirty tech entrepreneurs across the UK, which identified that seventy percent of the tech entrepreneurs that were interviewed agreed that technology maturity (i.e., the stage of technology in the technology S-curve) influences pivoting. Moreover, tech entrepreneurs prefer to pivot during the earlier stages of the technology S-curve (i.e., at the introduction stage of technology) because it is less time-consuming and more cost-effective. On the matter of whether pivoting leads to a change in the underlying technology for the tech startup, the findings were inconclusive, with roughly half of the interviewees stating there was a change, with the other half not agreeing with this position. Additionally, through the longitudinal interviews, the study has captured the viewpoints of tech entrepreneurs on categorising pivots based on the stages of technology in the technology S-curve. For example, product-level pivots are most pursued when a tech startup is in the introduction stage of the S-curve. Similarly, in the growth stage, the most pursued pivots are from the strategy-level category.

9.11.3.2 Impact of technology readiness levels on pivoting

The empirical results from the longitudinal interviews provided evidence that fifty-six percent of tech entrepreneurs believe that the levels of the technology readiness level influence pivoting. The tech entrepreneurs explained that pivoting when the core technology is at TRL 5 or below could be cost-effective. This finding is similar to the primary thirty interviews, where participants explained that pivoting during the earlier stages of the technology S-curve could be more cost-effective and less time-consuming.

9.11.4 Psychological ownership issues with business ideas

The study has found supporting evidence to the studies of Grime (2018), Crilly (2018) and Felix et al. (2018). Their study explained that entrepreneurs may potentially resist pivoting with respect to their initial business idea. The empirical results have supported the above statement, as sixty-seven percent of the tech entrepreneurs agreed that they felt psychological ownership towards their initial business idea.

9.11.5 Value proposition

The study found that 80% of the participants agreed that pivoting helps create and sustain the startup's value proposition. This study established firm evidence that pivots build an improved relationship between customers and tech startups through helping to create and sustain the value proposition. Ninety percent of the participants from the primary thirty interviews agreed that yes, they achieved the desired results after pivoting. Additionally, during the longitudinal interviews, the study asked the participants whether pivoting has positively or negatively impacted the startup's performance. All participants agreed that pivoting had positively impacted the startup's performance.

9.11.6 Emerging pivoting phenomena

The empirical study has provided evidence to substantiate and validate the emerging phenomenon of the domino effect in pivoting, where one pivot leads to further pivot(s). To understand further, through longitudinal interviews, the study classified pivots based on the domino effect (see Table 33). The study also discusses three significant challenges, i.e., persuading customers; pursuing stakeholders, partners, or suppliers; and onboarding resources the tech startups face while pursuing pivots.

9.12 Limitations

The research study is focused on understanding how high-tech entrepreneurs successfully pivot during their entrepreneurial journey as well as the evaluating the impact of technology maturity and other factors on the process of entrepreneurial pivoting. Therefore, the study conducted fifty-seven interviews (thirty primary interviews and twenty-seven longitudinal interviews). The results and corresponding discussions are presented in the previous chapters and the research questions have been addressed in this chapter. In this section, the limitations of this research study are provided, which are provided as follows:

1. The first limitation is that although the research study evaluates the influence of the Lean Startup Approach on startups, not all the tech startups selected through the purposive sampling technique were deliberately following followed the Lean Startup Approach—although twenty-nine tech startups out of thirty pursued pivoting.

2. The second limitation of the study is that a correlation between the type of pivot and the factors that cause entrepreneurial pivoting could not be identified. The study collected primary and secondary data using the qualitative research methodology and converted the data from qualitative to quantitative. However, more quantitative data would be needed to conduct the required form of statistical analysis to enable the correlation goal to be realised.
3. The third limitation is that the study focused on understanding the technology life cycle of the primary technology adopted by tech startups through the technology S-curve and its influence on entrepreneurial pivoting. In contrast, several tech startups use multiple technologies to build the company's MVP. Consequently, the study did not focus on how entrepreneurial pivoting can be influenced by multiple technologies according to the technology S-curves.
4. The fourth limitation is that the sample size (N=30) consists of only one tech startup that did not pursue a pivot. It would be helpful to understand more about the firms that did not pivot in their journey and their outlook on how the phases of TE influence pivoting and the impact of the stages of technology in the technology S-curve on pivoting.
5. The fifth limitation is that the study was confined to the United Kingdom and the results of the study may potentially be impacted by country specific factors and therefore different results could potentially be obtained in different countries and other parts of the world.

9.13 Future work

It is proposed that the limitations mentioned in the previous section are addressed in the following areas of future work as well as the additional areas that are identified:

1. Future studies are proposed to obtain empirical data from tech entrepreneurs that are deliberately using the LSA. This would potentially provide more data on how the LSA theory is utilised by practicing entrepreneurs. Studies could again involve qualitative data analysis from interviews or conversely may involve another method, for example, through capturing the viewpoints of several tech entrepreneurs collectively and gaining consensus on the findings through application of the Delphi technique (Barrett and Heale, 2020).
2. The second recommendation for future studies is to collect primary data in the form of quantitative data, for example, through use of a survey instrument with a sufficiently large number of tech entrepreneurs. This would allow statistical analysis, such as the Pearson correlation coefficient, multiple regression analysis or structural equation modelling to be conducted (Goodwin and Leech, 2006). These multivariate statistical techniques would help to determine whether there is a correlation between the factors that cause pivots and the different types of pivots that can be pursued by tech startups.
3. Since tech startups use multiple technologies to build the company's MVP, the third recommendation of the study for future work is to understand how entrepreneurial pivoting can be influenced by multiple technologies according to the technology s-curves. In this case, data will need to be obtained from tech startups on the different technologies that are utilised, including different parameters such as the type of technology, maturity, and other factors to be determined.
4. Future research is recommended to collect primary data with a sample size of thirty or more consisting of participants (i.e., tech entrepreneurs) who pursued pivots and those who did not pursue pivots. A study on firms that did not pivot in their journey and their outlook on the influence phases of TE on pivoting and the impact of stages of

technology in the technology S-curve on pivoting would allow a more comprehensive understanding of entrepreneurial pivoting to be developed.

5. A future study could comprise a comparative analysis of tech startups/firms based in developed economies such as the UK, USA, and Germany with developing economies such as China, India, and South Africa. Country-specific factors could lead to different empirical results, thereby enabling an understanding of entrepreneurial pivoting on a broader scale.
6. A further recommendation for future study is to conduct a qualitative research analysis to investigate the leadership styles of entrepreneurs in the context of psychological ownership issues. The study would collect the data from a larger sample size and employ appropriate sampling such as purposive sampling followed by snowballing. The empirical results would elaborate on how entrepreneurs have overcome the urge of resistance towards pivoting.
7. Finally, future research is suggested to focus on comparing the process of pivoting by tech startups with pivoting by companies from different industrial sectors (i.e., retail and FMCG (fast-moving consumer goods)) to assess the sector influence. Additionally, a comparative study is proposed that would assess entrepreneurial pivoting of tech startups with pivoting by more mature tech companies to assess the influence of company maturity on the process.
8. A circular economy's objective is to maximise value at each phase in the product's life cycle (Stachel, 2016). Similarly, LSA focuses on minimising the wastage of engineering hours and maximising customer value. The circular economy applies in the context of resource usage and environmental sustainability, while the lean startup approach applies in the context of business development. Future research should focus on companies which opted for LSA and are working within a circular economy to

evaluate how startups create and sustain value propositions while working on environmental sustainability.

References

Abu-Alhaija, A.S. (2019) From epistemology to Structural Equation Modelling: An essential guide in understanding the principles of research philosophy in Selecting the Appropriate Methodology, *Australian Journal of Basic and Applied Sciences*, 13 (9), pp.122-128.

Agee, J. (2009) Developing qualitative research questions: a reflective process, *International Journal of Qualitative Studies in Education*, 22 (4), pp.431-447.

Aldrich, H.E. (1992) Methods in our madness? trends in entrepreneurship research, in: Sexton, D.L. and Kasarda, J.D. (ed.) *The State of the Art of Entrepreneurship,* Boston: PWS-KENT, pp. 191-213.

Alrowwad, A., Abualoush, S.H. and Masa'deh, R. (2020) Innovation and intellectual capital as intermediary variables among transformational leadership, transactional leadership and organizational performance, *Journal of Management Development*, 39 (2), pp.196-222.

Antonakis, J., Bastardoz, N., Jacquart, P. and Shamir, B. (2016) Charisma: An Ill-Defined and Ill-Measured Gift, *Annual Review of Organizational Psychology and Organizational Behavior*, 3, pp.293-319.

Artinian, B.M., Giske, T. and Cone, P.H. (2009) *Glaserian grounded theory in nursing research: Trusting emergence.* New York: Springer Publishing Company.

Assarroudi, A., Nabavi, H.F., Armat, M.R., Ebadi, A. and Vaismoradi, M. (2018) Directed qualitative content analysis: the description and elaboration of its underpinning methods and data analysis process, *Journal of Research in Nursing*, 23 (1), pp.42-55.

Azevedo, V., Carvalho, M., Fernandes-Costa, F., Mesquita, S., Soares, J., Teixeira, F. and Maia, Â (2017) Interview transcription: Conceptual issues, practical guidelines, and challenges, *Revista De Enfermagem Referência,* 4 (14), pp.159-167.

Axelson, M. and Bjurström, E. (2019) The Role of Timing in the Business Model Evolution of Spinoffs, *Research Technology Management*, 62 (4), pp.19-26.

Bailey, J. (2008) First steps in qualitative data analysis: Transcribing, *Family Practice,* 25 (2), pp.127-131.

Bailetti, T. (2012) Technology Entrepreneurship: Overview, Definition, and Distinctive Aspects, *Technology Innovation Management Review,* 2 (2) pp.5–12.

Bajwa, S.S. Wang, X., Nguyen Duc, A. and Abrahamsson, P. (2017) "Failures" to be celebrated: an analysis of major pivots of software startups, *Empirical Software Engineering*, 22 (5), pp.2373-2408.

Banks, G.C., Engemann, K.N., Williams, C.E, Gooty, J., McCauley, D.K. and Medaugh, M.R. (2017) A meta-analytic review and future research agenda of charismatic leadership, *The Leadership Quarterly*, 28 (4), pp.508-529.

Basulto, D. (2015) *The 7 greatest pivots in tech history*. Available from: https://www.washingtonpost.com/news/innovations/wp/2015/07/02/the-7-greatest-pivots-in-tech-history/. [Accessed on 24 July 2023]

Baumol, W., Litan, E. and Schramm, J. (2007) *Good Capitalism, Bad capitalism and the economics of growth and prosperity.* New Haven: Yale University Press.

Bazeley, P. (2013) *Qualitative data analysis: Practical strategies.* London: SAGE.

Beckman, C.M., Eisenhardt, K., Kotha, S., Meyer, A. and Rajagopalan, N. (2012) Technology Entrepreneurship, *Strategic Entrepreneurship Journal,* 6 (2) pp.89–93.

Beckman, C.M., Eisenhardt, K., Kotha, S., Meyer, A. and Rajagopalan, N. (2012a) The role of the entrepreneur in technology entrepreneurship, *Strategic Entrepreneurship Journal*, 6 (3), pp.203–206.

Berends, H., Burg, E. and Garud, R. (2021) Pivoting or persevering with venture ideas: Recalibrating temporal commitments, *Journal of Business Venturing*, 36 (4), pp.1-20. DOI: doi.org/10.1016/j.jbusvent.2021.106126.

Biesta, G. and Bubules, N.C. (2003) *Pragmatism and educational research.* Lanham: Rowman and Littlefield.

Birks, M. and Mills, J. (2015) *Grounded theory: A practical guide.* London: SAGE.

Blank, S. (2013) Why the lean start-up changes everything, *Harvard Business Review*, 91 (5), pp.63-72.

Boeije, H. (2010) *Analysis in qualitative research*. London: SAGE.

Bogna, F., Raineri, A. and Dell, G. (2020) Critical realism and constructivism: merging research paradigms for a deeper qualitative study, *Qualitative Research in Organizations and Management: An International Journal*, 15 (4), pp.461-484.

Bohn, N. and Kundisch, D. (2018) Much more than "same solution using a different technology": Antecedents and consequences of technology pivots in software startups, in: *Proceedings of the Multikonferenz Wirtschaftsinformatik, Lüneburg (MKWI)*, Lüneburg, Germany, pp.526-537.

Boretti, A. (2021) Technology Readiness Level in Solar Thermochemical Splitting Cycles, *ACS Energy Letters*, 6 (4), pp.1170-1174.

Bortolini, R.F., Nogueira Cortimiglia, M., Danilevicz, A.d.M.F. and Ghezzi, A. (2021) "Lean Startup: a comprehensive historical review", *Management Decision*, 59 (8), pp.1765-1783.

Brenk, S., Lüttgens, D., Diener, K. and Piller, F. (2019) Learning from failures in business model innovation: solving decision-making logic conflicts through intrapreneurial effectuation. *Journal of Business Economics*, 89 (8), pp.1097-1147.

Britten, N., Jones, R., Murphy, E. and Stacy, R. (1995) Qualitative research methods in general practice and primary care, *Family Practice,* 12 (1), pp.104-114.

Brown, M., Brown, R.S. and Nandedkar, A. (2019) Transformational Leadership Theory and Exploring the Perceptions of Diversity Management in Higher Education, *Journal of Higher Education Theory and Practice*, 19 (7), pp.11-21.

Brush, C.G, Duhaime, I.M, Gartner, W.B, Stewart, A, Katz, J.A, Hitt, M.A, Alvarez, S.A, Meyer, G.D and Venkataraman, S. (2003) Doctoral education in the field of entrepreneurship, *Journal of Management*, 29 (3), pp.309-331.

Bryant, A. and Charmaz, K. (2007) *The Sage handbook of grounded theory*. London: SAGE.

BusinessNewsWales (2020) *Fintech wins multiple awards*. Available from: https://businessnewswales.com/fintech-start-up-wins-multiple-awards/. [Accessed 24 July 2023].

Byun, J., Sung T.E., and Park, H.W. (2018) Technological innovation strategy: how do technology life cycles change by technological area, *Technology Analysis & Strategic Management*, 30 (1), pp. 98-112.

Caillier, J.G. (2020) Testing the Influence of Autocratic Leadership, Democratic Leadership, and Public Service Motivation on Citizen Ratings of An Agency Head's Performance, *Public Performance and Management Review*, 43 (4), pp.918-941.

Camuffo, A., Cordova, A., Gambardella, A. and Spina, C. (2020) A Scientific Approach to Entrepreneurial Decision Making: Evidence from a Randomized Control Trial, *Management Science*, 66 (2), pp.564–586.

Chamberlain-Salaun, J., Mills, J. and Usher, K. (2013) Linking symbolic interactionism and grounded theory methods in a research design, *SAGE Open,* 3 (3), pp.1-10.

ChannelSight (2020) *COVID-19: 7 brands that have pivoted*. Available from: https://www.channelsight.com/blog/covid-19-brands-that-pivoted. [Accessed 24 July 2023].

Charmaz, K. (2006) *Constructing grounded theory: A practical guide through qualitative analysis*. California: SAGE.

Charmaz, K. (2009) *Developing Grounded Theory: The Second Generation*. New York: Routledge.

Charmaz, K. and Bryant, A. (2011) Grounded theory and credibility, in: Silverman, D (ed.) *Qualitative Research*. 3rd ed. London: SAGE, pp.291-309.

Charmaz, K. and Thornberg, R. (2021) The pursuit of quality in grounded theory, *Qualitative Research in Psychology*, 18 (3), pp.305-327.

Chun Tie, Y., Birks, M. and Francis, K. (2019) Grounded theory research: A design framework for novice researchers, *SAGE Open Medicine*. DOI: 10.1177/2050312118822927.

Churchill, N.C. (1992) Research issues in entrepreneurship. in: Sexton, D.L. and Kasarda, J.D. (ed.) *The State of the Art of Entrepreneurship,* Boston: PWS-KENT, pp.579-596.

Clarke, E. and Visser, J. (2019) Pragmatic research methodology in education: possibilities and pitfalls, *International Journal of Research & Method in Education*, 42 (5), pp.455-469.

Cleary, M., Horsfall, J. and Hayter, M. (2014) Data collection and sampling in qualitative research: does size matter?, *Journal of Advanced Nursing*, 70 (3), pp.473-475.

Coleman, G. and O'Connor, R. (2007) Using grounded theory to understand software process improvement: A study of Irish software product companies, *Information and Software Technology,* 49 (6), pp.654-667.

Contigiani, A. and Levinthal, D. A. (2019) Situating the construct of lean start-up: Adjacent conversations and possible future directions, *Industrial and Corporate Change,* 28 (3), pp. 551-564.

Cooper, D.R. and Schindler, P.S. (2014) *Business research methods*. 4th ed. Maidenhead: Mcgraw-hill.

Corbin, J. M. and Strauss, A. (1990) Grounded theory research: Procedures, canons, and evaluative criteria, *Qualitative Sociology,* 13 (1), pp.3-21.

Coyle, A. (2010) Qualitative Research and Anomalous Experience: A Call for Interpretative Pluralism, *Qualitative Research in Psychology,* 7 (1), pp.79–83.

Coyne, I. and Cowley, S. (2006) Using grounded theory to research parent participation, *Journal of Research in Nursing,* 11 (6), pp.501-515.

Creswell, J.W. (2014) *Research Design: Qualitative, Quantitative and Mixed methods*. 4th ed. California: SAGE.

Creswell, J.W. and Poth, C.N. (2017) *Qualitative inquiry and research design: Choosing among five approaches.* 4th ed. Los Angeles: SAGE

Cunningham, J.A. and Link, A.N. (2015) Fostering University-industry R&D Collaborations in European Union Countries, *International Entrepreneurship and Management Journal*, 11 (4), pp.849–860.

Cunningham, J.A, and Menter, M. (2021) Transformative change in higher education: entrepreneurial universities and high-technology entrepreneurship, *Industry and Innovation*, 28 (3), pp.343-364.

Dan, Y. and Chieh, H.C. (2008) A reflective review of disruptive innovation theory, in: *Portland International Conference on Management of Engineering and Technology (PICMET) 2008 Proceedings*, South Africa, 27-31 July, IEEE, pp.402-414.

Davidson, C. (2009) Transcription: Imperatives for qualitative research, *International Journal of Qualitative Methods*, 8 (2), pp.35-52.

Debarshi, N. and Farhat, Z. (2021) Bureaucratic Leadership at Ground Level: A Case Study of Block Development Officers in West Bengal (India), *Indian Journal of Public Administration*, 67 (2), pp.188-200.

DeCelles, K.A. and Pfarrer, M.D. (2004) Heroes or Villains? Corruption and the Charismatic Leader, *Journal of Leadership and Organizational Studies*, 11 (1), pp.67-77.

Dewey, J. (1916) The pragmatism of peirce, *The Journal of Philosophy, Psychology and Scientific Methods*, 13 (26), pp.709-715.

Dey, I. (1999) *Grounding grounded theory: Guidelines for grounded theory inquiry*. San Diego: Academic Press.

Devece, C., Peris-Ortiz, M. and Rueda-Armengot, C. (2016) Entrepreneurship during economic crisis: Success factors and paths to failure, *Journal of Business Research*, 69 (11), pp.5366–5370.

Dorf, R.C. and Byers, T.H. (2005) *Technology ventures*. New York: McGraw Hill.

Duff, P.A. and Roberts, C. (1997) The politics of transcription; transcribing talk: Issues of representation, *Tesol Quarterly,* 31 (1), pp.167-172.

Dunne, C. (2011) The place of the literature review in grounded theory research, *International Journal of Social Research Methodology,* 14 (2), pp.111-124.

Eisenhardt, K. (1989) Building theories from case study research, *Academy of Management Review*, 14 (4), pp.532-550.

Eisenmann, T.R, Ries, E, and Dillard, S. (2012) Hypothesis-driven entrepreneurship: The lean startup, *Harvard Business School Entrepreneurial Management Case,* (812-095), pp.1-26.

Eliakis, S., Kotsopoulos, D., Karagiannaki, A. and Pramatari, K. (2020) Survival and growth in Innovative Technology Entrepreneurship: A mixed method investigation, *Administrative Sciences*, 10 (39), pp.1-35.

Elo, S., Kääriäinen, M., Kanste, O., Pölkki, T., Utriainen, K. and Kyngäs, H. (2014) Qualitative content analysis: A focus on trustworthiness, *SAGE Open*, 4 (1), pp.1-10.

Emans, R. (1970) A Schema for the Classification of Conceptual Frameworks Involving Reading, *Journal of Reading Behavior*, 3 (2), pp.15-21.

Ernst, B.A., Banks, G.C., Loignon, A.C., Frear, K.A., Williams, C.E., Arciniega, L.M., Gupta, R.K., Kodydek, G. and Subramamian, D. (2021) Virtual charismatic leadership and signaling theory: A prospective meta-analysis in five countries, *The Leadership Quarterly*. DOI: https://doi.org/10.1016/j.leaqua.2021.101541.

Eroglu, O, and Piçak, M. (2011) Entrepreneurship, national culture and turkey, *International Journal of Business and Social Science,* 2 (16), pp.146-151.

Felin, T., Gambardella, A., Stern, S. and Zenger, T. (2020) Lean startup and the business model: Experimentation revisited, *Long Range Planning,* 53 (4), pp.1-6.

Felix, C., Aparicio, S. and Urbano, D. (2018) Leadership as a driver of entrepreneurship: an international exploratory study, *Journal of Small Business and Enterprise Development*, 26 (3), pp.397-420.

Fellnhofer, K. and Puumalainen, K. (2017) Can role models boost entrepreneurial attitudes?, *International Journal of Entrepreneurship and Innovation Management*, 21 (3), pp.274-290.

Ferreira, J, Ferreira, F, Fernandes, C, Jalali, M, Raposo, M, and Marques, C. (2015) What do we (not) know about technology entrepreneurship research? *International Entrepreneurship Management Journal*, 12 (3), pp.713–733.

Ferreira, J.J, Fernandes, C.I, and Kraus, S. (2019) Entrepreneurship research: mapping intellectual structures and research trends, *Review of Managerial Science*, 13 (1), pp.181-205.

Flechas Chaparro, X. and de Vasconcelos Gomes, L. (2021), Pivot decisions in startups: a systematic literature review, *International Journal of Entrepreneurial Behavior and Research*, 27 (4), pp.884-910.

Ford, D. and Ryan, C. (1981) Taking technology to market, *Harvard Business Review*, 59 (2), pp.117-126.

Frank, H, and Landström, H. (2016) What makes entrepreneurship research interesting? Reflections on strategies to overcome the rigour–relevance gap, *Entrepreneurship & Regional Development*, 28 (1-2), pp.51-75.

Frederiksen, D.L, and Brem, A. (2017) How do entrepreneurs think they create value? A scientific reflection of Eric Ries' Lean Startup approach, *International Entrepreneurship and Management Journal*, 13 (1), pp.169-189.

Fryges, H. and Wright, M. (2014) The origin of spin-offs: a typology of corporate and academic spin-offs, *Small Business Economics*, 43, pp.245-259.

Fusch, P., Fusch, G.E. and Ness, L.R. (2018) Denzin's Paradigm Shift: Revisiting Triangulation in Qualitative Research, *Journal of Social Change*, 10 (1), pp.19-32.

García-Gutiérrez, I. and Martínez-Borreguero, F.J. (2016) The Innovation Pivot Framework: Fostering Business Model Innovation in Startups, *Research Technology Management*, 59 (5), pp.48-56.

García-Morales, V.J., Bolívar-Ramos, M.T. and Martín-Rojas, R. (2014) Technological variables and absorptive capacity's influence on performance through corporate entrepreneurship. *Journal of Business Research*, 67 (7), pp.1468-1477.

Gartner, W.B. (2001) Is there an elephant in entrepreneurship? Blind assumptions in theory development, *Entrepreneurship Theory and Practice*, 25 (4), pp.27–40.

Gartner, W.B. and Birley, S. (2002) Introduction to the special issue on qualitative methods in entrepreneurship research, *Journal of Business Venturing,* 17 (5), pp.387-395.

Gebel, M. (2019) *9 of the biggest pivots in tech history, from Nintendo to Instagram*. Available from: https://www.businessinsider.com/tech-company-biggest-pivots-nintendo-instagram-amazon-2019-8?r=US&IR=T#nintendos-history-goes-all-the-way-back-to-

1889-founder-fusajiro-yamauchi-began-manufacturing-hanafuda-cards-a-type-of-japanese-playing-card-for-his-company-nintendo-koppai-2. [Accessed 24 July 2023].

Ghezzi, A. (2019) Digital startups and the adoption and implementation of lean startup approaches: Effectuation, bricolage and opportunity creation in practice, *Technological Forecasting and Social Change,* 146, pp.945-960.

Ghezzi, A. and Cavallo, A. (2020) Agile business model innovation in digital entrepreneurship: Lean startup approaches, *Journal of business research*, 110, pp.519-537.

Giones, F., Zhou, Z., Miralles, F. and Katzy, B. (2013) From Ideas to Opportunities: Exploring the Construction of Technology-Based Entrepreneurial Opportunities. *Technology Innovation Management Review,* 3 (6) pp.13–20.

Giones, F. and Brem, A. (2017) Digital Technology Entrepreneurship: A Definition and Research Agenda. *Technology Innovation Management Review,* 7 (5), pp.44-51.

Glaser, B.G. (1978). *Theoretical sensitivity*. California: Sociology Press.

Glaser, B.G. and Strauss, A.L. (2017) *Discovery of grounded theory: Strategies for qualitative research*. New York: Routledge.

Glaveski, S. (2018) *The Top 10 Company Pivots of All-Time*. Available from: https://www.collectivecampus.io/blog/the-top-10-company-pivots-of-all-time. [Accessed 24 July 2023].

Gesler, W.M. (1999) Words in wards: Language, health and place, *Health and Place,* 5 (1), pp.13-25.

Goertz, G. and Mahoney, J. (2012) Concepts and measurement: Ontology and epistemology, *Social Science Information*, 51 (2), pp.205-216.

Goodwin, L.D. and Leech, N.L. (2006) Understanding Correlation: Factors that affect the size of r, *The Journal of Experimentation Education*, 74 (3), pp.249-266.

Grimes, M.G. (2018) The pivot: How founders respond to feedback through idea and identity work, *Academy of Management Journal*, 61 (5), pp.1692-1717.

Guba, E.G. and Lincoln, Y.S. (1994) Competing paradigms in qualitative research. in: Denzin, N.K and Lincoln Y.S. (ed.) *Handbook of qualitative research*, California: SAGE, pp.105-117.

Guetterman, T.C., Babchuk, W.A., Howell Smith, M.C. and Stevens, J. (2019) Contemporary approaches to mixed methods–grounded theory research: A field-based analysis, *Journal of Mixed Methods Research,* 13 (2), pp.179-195.

Guo, H., Yang, J. And Han, J. (2021) The Fit Between Value Proposition Innovation and Technology Innovation in the Digital Environment: Implications for the performance of Startups, *IEEE Transactions on Engineering Management*, 68 (3), pp.797-809.

Halcomb, E.J. and Davidson, P.M. (2006) Is verbatim transcription of interview data always necessary?, *Applied Nursing Research*, 19 (1), pp.38-42.

Hannes, K. and Lockwood, C. (2011) Pragmatism as the philosophical foundation for the joanna briggs meta-aggregative approach to qualitative evidence synthesis, *Journal of Advanced Nursing,* 67 (7), pp.1632-1642.

Hampel, C.E., Tracey, P. and Weber, K. (2020) The art of the pivot: How new ventures manage identification relationships with stakeholders as they change direction, *Academy of Management Journal*, 63 (2), pp.440-471.

Hannes, K. and Lockwood, C. (2011) Pragmatism as the philosophical foundation for the joanna briggs meta-aggregative approach to qualitative evidence synthesis, *Journal of Advanced Nursing,* 67 (7), pp.1632-1642.

Have, P.T. (1999) *Conversation analysis: A practical guide*. California: SAGE.

Harms, P.D., Wood, D., Landay, K., Lester, P.B. and Lester, G.V. (2018) Autocratic leaders and authoritarian followers revisited: A review and agenda for the future, *The Leadership Quarterly*, 29 (1), pp.105-122.

Harms, R. and Schwery, M. (2020) Lean startup: operationalizing lean startup capability and testing its performance implications, *Journal of small business management*, 58 (1), pp.200-223.

Hathcoat, J.D., Meixner, C. And Nicholas, M.C. (2019) Ontology and Epistemology, in: Pranee Liamputtong (ed.) *Handbook of Research Methods in Health Social Sciences*, Singapore: Springer, pp.99-116.

Heath, C. (1997) The analysis of activities in face to face interaction using video, in: Silverman, D. (ed.) *Qualitive Sociology,* London: SAGE, pp.183-200.

Hermanowicz, J.C. (2013) The Longitudinal Qualitative Interview, *Qualitative Sociology*, 36 (2), pp.189-208.

Hickman, L.A. and Alexander, T.M. (1998) *The essential Dewey, volume 1: Pragmatism, education, democracy*. Bloomington and Indianapolis: Indiana University Press

Hinchliffe, R. (2020) *Moven shuts all consumer accounts, pivots to B2B-only service for banks*. Available from: https://www.fintechfutures.com/2020/03/moven-shuts-all-consumer-accounts-pivots-to-b2b-only-service-for-banks/. [Accessed 24 July 2023].

Hirvikoski, K. (2014), “Startups pivoting towards value”, in Data and Value-Driven Software Engineering with Deep Customer Insight, in: *Proceedings of the Seminar*, pp. 1-7, No. 58314308.

Hogg, M.A. (2021) Uncertain Self in a Changing World: A foundation for Radicalisation, Populism and Autocratic Leadership, *European Review of Social Psychology*, 32 (2), pp.235-268.

Hughes, J.A. and Sharrock, W.W. (2016) *The Philosophy of Social Research*. 3rd ed. London: Routledge.

Hutton, G. (2022) *Business Statistics*. Available from: https://researchbriefings.files.parliament.uk/documents/SN06152/SN06152.pdf [Accessed 17/10/2023].

James, W. (1975) *Pragmatism.* Cambridge: Harvard University Press.

Jia, X., Chen, J., Mei, L. and Wu, Q. (2018) How leadership matters in organizational innovation: a perspective of openness, *Management Decision*, 56 (1), pp.6-25.

Johnson, R.B. and Onwuegbuzie, A. J. (2004) Mixed Methods Research: A Research Paradigm Whose Time has Come, *Educational Researcher*, 33 (7), pp.14–26.

Jones-Evans, D. (1995), A typology of technology-based entrepreneurs: A model based on previous occupational background. *International Journal of Entrepreneurial Behavior and Research*, 1 (1), pp.26-47.

Jones, P, and Colwill, A. (2013) Entrepreneurship education: an evaluation of the Young Enterprise Wales initiative, *Education + Training*, 55 (8-9), pp.911-925.

Kadwa, I. and Barnard, B. (2019) The impact of Leadership on Entrepreneurship and Innovation: Perceptions of Entrepreneurs, *The IUP Journal of Entrepreneurship Development*, 24 (4), pp.7-43.

Karasakal, E. and Aker, P. (2017), A multicriteria sorting approach based on data envelopment analysis for R&D project selection problem, *Omega*, 73, pp.79-92.

Karim, A., Purnomo, H., Fikriyah, F. and Kardiyati, E.N. (2020) A Charismatic Relationship: How a Kyai's Charismatic Leadership and Society's Compliance are Constructed?, *Journal of Indonesian Economy and Business*, 35 (2), pp.129-143.

Khajeh, E.H.Al. (2018) Impact of Leadership Styles on Organizational Performance, *Journal of Human Resource Management Research*, 2018, pp.1-10. DOI: 10.5171/2018.687849.

Khan, M.S., Khan, I., Qureshi, Q.A., Ismail, H.M., Rauf, H., Latif, A. and Tahir, M. (2015) The Styles of Leadership: A Critical Review, *Public Policy and Administration Research*, 5 (3), pp.87-92.

Kilintzis, P., Avlogiaris, G., Samara, E. and Bakouros, Y. (2022) Technology Entrepreneurship: A Model for the European Case. *Journal of the Knowledge Economy*, pp.1-26. DOI: 10.1007/s13132-022-00950-x.

Kirchberger, M., Wouters, M. and Anderson, J.C. (2020) How Technology-Based Startups Can Use Customer Value Propositions to Gain Pilot Customers, *Journal of Business-to-Business Marketing*, 27 (4), pp. 352-374.

Kirtley, J. and O'Mahony, S. (2020) What is a pivot? Explaining when and how entrepreneurial firms decide to make strategic change and pivot, *Strategic Management Journal*, pp.1–34. DOI: doi.org/10.1002/smj.3131.

Kivunja, C. (2018) Distinguishing between Theory, Theoretical Framework, and Conceptual Framework: A Systematic Review of Lessons from the Field, *International Journal of Higher Education*, 7 (6), pp.44-53.

Konior, J. and Szostak, M. (2020) The S-curve as a Tool for Planning and Controlling of Construction Process – Case Study, *Applied Sciences*, 10 (6), pp.1-14.

Kraus, S., Raj, V. and Walsh, S.T. (2021) The importance of literature reviews in small business and entrepreneurship research, *Journal of Small Business Management*, pp.1-5. DOI: 10.1080/00472778.2021.1955128.

Kucharavy, D, and De Guio, R. (2011) Application of S-shaped curves, *Procedia Engineering,* 9, pp.559-572.

Kuckartz, U. (2019) Qualitative text analysis: A systematic approach. in: Kaiser, G. and Presmeg, N. (ed.) *Compendium for early career researchers in mathematics education*. Springer Open, pp.181-197.

Kumar, A. (2020) *22 businesses pivoting through COVID-19*. Available from: https://www.maddyness.com/uk/2020/06/09/22-businesses-pivoting-through-covid-19/. [Accessed 24 July 2023].

Kwan, P. (2020) Is Transformational Leadership Theory Passé? Revisiting the Integrative Effect of Instructional Leadership and Transformational Leadership on Student Outcomes, *Educational Administration Quarterly*, 56 (2), pp.321-349.

Landström, H. (2005). *Pioneers in entrepreneurship and small business research.* New York: Springer

Leach Sankofa, N. (2021) Transformativist Measurement Development Methodology: A Mixed Methods Approach to Scale Construction, *Journal of Mixed Methods Research*. DOI: 10.1177/15586898211033698.

Lee, P. (2006) Bridging cultures: Understanding the construction of relational identity in intercultural friendship, *Journal of Intercultural Communication Research,* 35 (1), pp.3-22.

Leitch, C.M. and Volery, T. (2017) Entrepreneurship leadership: Insights and directions, *International Small Business Journal*, 35 (2), pp.147-156.

Leshem, S. and Trafford, V. (2007) Overlooking the conceptual framework, *Innovations in Education and Teaching International*, 44 (1), pp.93-105.

Lewin, A. and Silver, C. (2007) *Using software in qualitative research: A step-by-step guide*. London: SAGE.

Lincoln, Y.S. and Denzin, N.K. (2011) *The handbook of qualitative research.* 4th ed. California: SAGE.

Low, M.B, and MacMillan, I.C. (1988) Entrepreneurship: Past research and future challenges, *Journal of Management*, 14 (2), pp.139-161.

Maarouf, H., (2019) Pragmatism as a supportive paradigm for the mixed research approach: Conceptualizing the ontological, epistemological, and axiological stances of pragmatism, *International Business Research*, 12 (9), pp.1-12.

MacLean, L.M., Meyer, M. and Estable, A., (2004) Improving accuracy of transcripts in qualitative research, *Qualitative health research*, 14 (1), pp.113-123.

Mankins, J.C. (2009) Technology readiness assessment: A retrospective, *Acta Astronautica*, 65 (9-15), pp.1216-1223.

Martino, J. P. (1993a) *Technological forecasting for decision making.* 3rd ed. New York: McGraw-Hill, Inc.

Mattimoe, R., Hayden, M.T., Murphy, B. and Ballantine, J. (2021) Approaches to Analysis of Qualitative Research Data: A Reflection on the Manual and Technological Approaches, *Accounting, Finance, and Governance Review,* 27 (1), pp.22026.

McCann, T.V. and Clark, E. (2003a) Grounded theory in nursing research: Part 1–Methodology, *Nurse Researcher*, 11 (2), pp.7-18.

McDonald, R. and Gao, C. (2019) Pivoting isn't enough? Managing strategic reorientation in new ventures, *Organization Science*, 30 (6), pp.1289-1318.

McMullen, J.S. (2017) Are you pivoting away your passion? the hidden danger of assuming customer sovereignty in entrepreneurial value creation, *Business Horizons*, 60 (4), pp. 427-430.

McNabb, D.E. (2017) *Research methods in public administration and nonprofit management: quantitative and qualitative approaches*. 2nd ed. New York: M.E. Sharpe Inc.

Mkansi, M. and Acheampong, E.A. (2012) Research philosophy debates and classifications: students' dilemma, *Electronic journal of business research methods*, 10 (2), pp.132-140.

Molina-Azorín, J.F, López-Gamero, M.D, Pereira-Moliner, J, and Pertusa-Ortega, E.M. (2012) Mixed methods studies in entrepreneurship research: Applications and contributions, *Entrepreneurship & Regional Development,* 24 (5-6), pp.425-456.

Mohamad, H.M., Mohamad, M.I., Saad, I., Bolong, N., Mustazama, J. and Razali, S.N.M (2021), A Case Study of S-Curve Analysis: Causes, Effects, Tracing and Monitoring project Extension of Time, *Civil Engineering Journal*, 7 (4), pp.649-661.

Molly, V., Laveren, E. and Deloof, M. (2010) Family business succession and its impact on financial structure and performance, *Family Business Review*, 23 (2), pp.131-147.

Moore, G.A. (2007), Dealing with Darwin: How Great Companies Innovate at Every Phase of their Evolution, *Strategic Direction*, 23 (9). DOI: https://doi.org/10.1108/sd.2007.05623iae.001.

Morgan, B. (2020) *10 examples of how COVID-19 forced business transformation*. Available from: https://www.forbes.com/sites/blakemorgan/2020/05/01/10-examples-of-how-covid-19-forced-business-transformation/#1f9c7681be35. [Accessed 24 July 2023].

Morgan, T., Anokhin, S., Ofstein, L. and Friske, W. (2020) SME response to major exogenous shocks: The bright and dark side of business model pivoting, *International Small Business Journal: Research Entrepreneurship*, 38 (5), pp.369-379.

Mosey, S., Guerrero, M. and Greenman, A. (2017) Technology entrepreneurship research opportunities: Insights from across Europe, *Journal of Technology Transfer*, 42 (1), pp.1–9.

Murmann, J.P. and Frenken, K. (2006) Toward a systematic framework for research on dominant designs, technological innovations and industrial change, *Research Policy*, 35 (7), pp.925-952.

Mwita, K.M. (2022) Factors influencing data saturation in qualitative studies, *International Journal of Research in Business and Social Science*, 11 (4), p.414-420.

Nacu, C.M. and Avasilcai, S. (2014) Environmental factors influencing technological entrepreneurship: Research framework and results, *Procedia - Social and Behavioral Sciences*, 109, pp.309–1315.

Nambisan, S. (2017) Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship, *Entrepreneurship Theory and Practice*, 41 (6), pp.1029-1055.

Nazar, J. (2013) *14 Famous Business Pivots*. Available from: https://www.forbes.com/sites/jasonnazar/2013/10/08/14-famous-business-pivots/#2ccbae157978. [Accessed 24 July 2023].

Nazarov, M., Butryumva, N. and Sidorov, D. (2015) Development of technology entrepreneurship in a transition economy: An example of the Russian region with high scientific potential. In DIEM: *Dubrovnik International Economic Meeting 2017. 3rd Dubrovnik International Economic Meeting, Scientific Conference on Managing Business Growth in a Volatile Environment*. Dubrovnik: University of Dubrovnik.

Negrao, L.L.L., Lopes de Sousa Jabbour, A.B., Latan, H., Filho, M.G., Jabbour, C.J.C., and Ganga, G.M.D. (2019) Lean manufacturing and business performance: testing the S-curve theory, *Production Planning and Control,* 31 (10), pp. 771-785.

Netland, T.H. and Fedrows, K. (2016) The S-curve effect on Lean Implementation, *Production and Operations Management*, 25 (6), pp.1106-1120.

Nightingale, P. and Coad, A. (2013) Muppets and gazelles: political and methodological biases in entrepreneurship research, *Industrial and Corporate Change*, 23 (1), pp.113–143.

O'Connor, G., Corbett, A.C. and Peters, L.S. (2018a) *Beyond the Champion: Institutionalizing Innovation through People*. California: Stanford University Press.

O'Connor, G., Leifer, R., Paulson, A. and Peters, L.S. (2018b) *Grabbing Lightening: Building a Capability for Breakthrough Innovation*. California: Jossey-Bass.

O'Hear, S. and Lomas, N. (2014) *Five Super Successful Tech Pivots*. Available from: https://techcrunch.com/gallery/five-super-successful-tech-pivots/. [Accessed on 24 July 2023].

Olechowski, A., Eppinger, S.D. and Joglekar, N. (2015) Technology Readiness Levels at 40: A Study of State-of-the-Art Use, Challenges, and Opportunities, in: *2015 Portland International Conference on Management of Engineering and Technology (PICMET)*, Portland, 2 August, pp.2084-2094. Doi: 10.1109/PICMET.2015.7273196.

Osterwalder, A, and Pigneur, Y. (2010) *Business model generation: a handbook for visionaries, game changers, and challengers* (Vol. 1). New Jersey: John Wiley & Sons.

Oswald, J. and Gatrell, C. (2014) Editorial: The Future of Writing and Reviewing for IJMR, *International Journal of Management Reviews*, 16 (3), pp.249-264.

Overall, J. and Wise, S (2015) "An S-curve Model of the Start-Up Life Cycle Through the Lens of Customer Development," *The Journal of Private Equity,*18 (2), pp. 23-34.

Palmatier, R.W., Houston, M.B. and Hulland, J. (2018) Review articles: purpose, process and structure, *Journal of the Academy of Marketing Science*, 46, pp.1-5.

Pansiri, J. (2005) Pragmatism: A methodological approach to researching strategic alliances in tourism, *Tourism and Hospitality Planning and Development*, 2 (3), pp.191-206.

Pathak, S., Xavier-Oliveira, E. and Laplume, A.O. (2013) Influence of intellectual property, foreign investment, and technological adoption on technology entrepreneurship, *Journal of Business Research*, 66 (10), pp.2090–2101.

Patton, M.Q. (2002) *Qualitative research and evaluation methods.* 3rd ed. California: SAGE.

Philbin, S.P. (2013) Managing university-industry research partnerships through a process of alignment. In *2013 Proceedings of PICMET'13: Technology Management in the IT-Driven Services (PICMET),* IEEE, pp. 1848-1859.

Pillai, S.D., Goldfrab, B. and Kirsch, D.A. (2020) The origins of firm strategy: Learning by economic experimentation and strategic pivots in the early automobile industry, *Strategic Management Journal*, 41 (3), pp.369-399.

Pollock, J.M., Carr, J.C., Corbett, A.C., Hoyt, C.L., Kellermanns, F.W., Kirkman, B.L. and Post, C. (2020) Contextual and Interactional Approaches to Advancing Leadership and Entrepreneurship Research, *Journal of Management Studies*, 57 (5), pp.915-930.

Pope, C., Ziebland, S. and Mays, N. (2000) Qualitative research in health care: Analysing qualitative data, *British Medical Journal,* 320, pp.114-116. DOI: 10.1136/bmj.320.7227.114

Prasetio, E. A., Yuana, R. and Anggarini L. T. (2020), Increasing Technology-Based Startup Grant Effectiveness, *International Journal of Innovation, Creativity and Change*, 11 (01), pp.204-220.

Pruitt, J. (2017) *4 Companies and How They Successfully Pivoted*. Available from: https://www.inc.com/jeff-pruitt/4-companies-and-how-they-successfully-pivoted.html. [Accessed 24 July 2023].

Purwanto, A., Bernarto, I., Asbari, M., Wijayanti, L.M. and Hyun, C.C. (2020) Effect of transformational and transactional leadership style on public health centre performance, *Journal of Research in Business, Economics, and Education*, 2 (1), pp.304-314.

Ratten, V, and Jones, P. (2021) Covid-19 and entrepreneurship education: Implications for advancing research and practice, *The International Journal of Management Education*, 19 (1), pp.1-10.

Raziq, M.M., Borini, F.M., Mailk, O.F., Mansoor, A. and Shabaz, M. (2018) Leadership styles, goal clarity, and project success, *Leadership and Organization Development Journal*, 39 (2), pp.309-323.

Reid, S.W., Anglin, A.H., Baur, J.E., Short, J.C. and Buckley, M.R. (2018) Blazing new trails or opportunity lost? Evaluating research at the intersection of leadership and entrepreneurship, *The Leadership Quarterly*, 29 (1), pp.150–164.

Rejeb, H.B., Morel-Guimaraes. L., Bolv, V. and Assielou, N.G. (2008) Measuring innovation best practices: Improvement of an innovation index integrating threshold and synergy effects, *Technovation*, 28 (12), pp.838-854.

Ries, E. (2011), *The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*, London: Penguin Group.

Riga, F. (2020) Pragmatism – John Dewey. in: Akpan, B. and Kennedy, T.J. (ed.) *Science Education in Theory and Practice.* Springer Text in Education. Springer, Cham, pp.227-239.

Ringle, H. (2017) *Tallwave triples employees and offers digital marketing with new acquisition*. Available from: https://www.bizjournals.com/phoenix/news/2017/03/31/tallwave-triples-employees-and-offers-digital.html. [Accessed 24 July 2023].

Roberts, E.B. and Liu, W.K. (2001) Ally or acquire?, *MIT Sloan Management Review*, 43 (1), pp.1-18.

Rocco, T.S. and Plakhotnik, M.S. (2009) Literature reviews, conceptual frameworks, and theoretical frameworks: Terms, functions, and distinctions, *Human Resource Development Review*, 8 (1), pp.120-130.

Rybicka, J., Tiwari, A. and Leeke, G.A. (2016) Technology readiness level assessment of composites recycling technologies, *Journal of Cleaner Production*, 112 (1), pp.1001-1012.

Sadeghiani, A., Anderson, A., Ahmadi, S. and Shokouhyar, S. (2021) Theorizing pivot in small and micro business, *Journal of Small Business and Entrepreneurship*, pp.1-19. DOI: 10.1080/08276331.2021.2014205.

Saeed, M. and Mughal, Y.H. (2019) Role of transactional leadership style upon performance: Mediating role of culture, *Journal of Managerial Sciences*, 13 (1), pp.47-57.

Saldana, J. (2013) *The coding manual for qualitative researchers*. 2nd (ed.) London: SAGE.

Salim, F. and Abu, N.A. (2020) An S-curve Model on the Maximum Predictive Pricing of Used Cars, *European Journal of Molecular and Clinical Medicine*, 7 (2), pp.907-921.

Saingchokyoo, N., Klinger, R.L. and Campion, E.D. (2020) Follower transformation as the linchpin of transformational leadership theory: A systematic review and future research agenda, *The Leadership Quarterly*, 31 (1), pp.1-18.

Saunders, B., Sim, J., Kingstone, T. Baker, S., Waterfield, J., Bartlam, B., Burroughs, H. and Jinks, C. (2018) Saturation in qualitative research: exploring its conceptualization and operationalization, *Quality and Quantity*, 52 (4), pp.1893-1907.

Saunders, M. and Lewis, P., Thornhill, A. (2019) *Research methods for business students*. 8th ed. Essex: Pearson Education Ltd.

Scheffler, I. (1974) *Four pragmatists: A critical introduction to Peirce, James, Mead, and Dewey.* London: Routledge.

Schegloff, E. A. (1997) Whose text? whose context?, *Discourse and Society,* 8 (2), pp.165-187.

Schilling, M.A. and Esmundo, M. (2009) Technology S-curves in renewable energy alternatives: Analysis and implications for industry and government, *Energy Policy*, 37 (5), pp.1767-1781.

Schmitz, A, Urbano, D, Dandolini, G.A, De Souza, J.A, and Guerrero, M. (2017) Innovation and entrepreneurship in the academic setting: a systematic literature review, *International Entrepreneurship and Management Journal,* 13 (2), pp.369-395.

Schumpeter, J.A. (1939) *Business cycles*. New York: Mcgraw-hill.

Sekaran, U. and Bougie, R. (2016) *Research methods for business: A skill building approach*. 7th ed. Chichester: John Wiley and Sons.

Shane, S. and Venkataraman, S. (2003) Guest editors' introduction to the special issue on technology entrepreneurship, *Research Policy*, 33 (2), pp.181–184.

Shepherd, D.A, and Gruber, M. (2020) The lean startup framework: Closing the Academic–Practitioner divide, *Entrepreneurship Theory and Practice,* 45 (5), pp.967-998.

Simone, P. (2002) A grounded theory of beer consumption in australia, *Qualitative Market Research: An International Journal,* 5 (2), pp.112-122.

Silverman, D. (2017) *Doing qualitative research: A practical handbook.* 8th ed. London: SAGE.

Sood, A. and Tellis, G.J. (2005) Technological evolution and radical innovation, *Journal of Marketing,* 69 (3), pp.152-168.

Spiegel, M. and Marxt, C. (2011) Defining technology entrepreneurship, in: *2011 IEEE International Conference on Industrial Engineering and Engineering Management,* IEEE, pp.1623-1627.

Srnka, K.J. and Koeszegi, S.T. (2007) From words to numbers: How to transform qualitative data into meaningful quantitative results, *Schmalenbach Business Review,* 59 (1), pp.29-57.

Stahel, W. (2016) The circular economy, *Nature*, 531 (7595), pp.435-438.

Straub, J. (2015) In search of technology readiness level (TRL) 10, *Aerospace Science and Technology*, 46, pp.312-320.

Strauss, A. and Corbin, J. (1998) *Basics of qualitative research: Techniques and procedures for developing grounded theory*. 2nd ed. California: SAGE.

Stuckey, H. L. (2014) Methodological issues in social health and diabetes research, *Journal of Social Health and Diabetes,* 2 (1), pp.6-8.

Sudarmiatin, S., Wiguna, R.T., Fitri, R. and Attan, R.B. (2021) Pivot Strategy in Entrepreneurship: Strategy of Managing Business During Coronavirus Pandemic, *International Journal of Multicultural and Multireligious Understanding*, 8 (9), pp.491-500.

Suddaby, R. (2010) Editor's comments: Construct clarity in theories of management and organization, *Academy of Management Review,* 35 (3), pp.346-357.

Suddaby, R., Bruton, G.D. and Si, S.X. (2015) Entrepreneurship through a qualitative lens: Insights on the construction and/or discovery of entrepreneurial opportunity, *Journal of Business Venturing,* 30 (1), pp.1-10.

Superscript (2020) *Most successful business pivots in history*. Available from: https://gosuperscript.com/blog/most-successful-business-pivots-in-history/. [Accessed 24 July 2023].

Syamsidar, Lian, B. and Fitriani, Y. (2021) Application of Democratic Leadership Style in Improving Employee Work Discipline and Motivation, *Indonesian Science Education Journal*, 2 (1), pp.1-11.

Talisse, R.B. and Aikin, S.F. (2008) *Pragmatism: A guide for the perplexed*. London: Continuum.

Tanev, S., Rasmussen, E. S., Zijdemans, E., Lemminger, R. and Svendsen, L.L. (2015) Lean and global technology start-ups: Linking the two research streams, *International Journal of Innovation Management*, 19 (03), pp.1-41.

Taylor, M, and Taylor, A. (2012) The technology life cycle: Conceptualization and managerial implications, *International Journal of Production Economics,* 140 (1), pp.541-553.

Teddlie, C. (2005) Methodological Issues Related to Causal Studies of Leadership, *Educational Management Administration and Leadership,* 33 (2), pp.211–227.

Teece, D.J. (2018) Business models and dynamic capabilities, *Long Range Planning*, 51 (1), pp.40-49.

Tilley, S.A. (2003) “Challenging” research practices: Turning a critical lens on the work of transcription, *Qualitative Inquiry,* 9 (5), pp.750-773.

Thornhill, A., Saunders, M. and Lewis, P. (2009) Research methods for business students, *Essex: Pearson Education Ltd*.

Trede, F. and Higgs, J. (2009) Framing research questions and writing philosophically: The role of framing research questions. in: Higgs, J., Horsfall, D. and Grace, S. (ed). *Writing qualitative research on practice*, Rotterdam: Sense, pp.13-25.

Trumbo, C.W. (2004) Research methods in mass communication research: A census of eight journals 1990–2000, *Journalism & Mass Communication Quarterly,* 81 (2), pp.417-436.

Tushman, M.L. and Anderson, P. (2004) *Managing strategic innovation and change: A collection of readings*. 2nd ed. Oxford University Press.

Urbano, D. and Turró, A. (2013) Conditioning factors for corporate entrepreneurship: an in (ex) ternal approach. *International entrepreneurship and management journal*, 9 (3), pp.379-396.

Urbano, D, Guerrero, M, Ferreira, J.J, and Fernandes, C.I. (2019) New technology entrepreneurship initiatives: Which strategic orientations and environmental conditions matter in the new socio-economic landscape, *The Journal of Technology Transfer*, 44 (5), pp.1577-1602.

Unterkalmsteiner, M., Abrahamsson, P., Wang, X., Nguyen-Duc, A., Shah, S.Q., Bajwa, S.S., Baltes, G.H., Conboy, K., Cullina, E., Dennehy, D. and Edison, H. (2016) Software startups–a research agenda, *e-Informatica Software Engineering Journal*, 10 (1), pp.89-123.

Venkataraman, S. (1997) The distinctive domain of entrepreneurship research, *Advances in Entrepreneurship, Firm Emergence and Growth,* 3 (1), pp.119-138.

Vohora, A, Wright, M, and Lockett, A. (2004) Critical junctures in the development of university high-tech spinout companies, *Research Policy,* 33 (1), pp.147-175.

Vollstedt, M. and Rezat, S. (2109) An introduction to Grounded Theory with a Special Focus on Axial Coding and Coding Paradigm. in: Kaiser, G. and Presmeg, N. (ed.) *Compendium for early career researchers in mathematics education*. Springer Open, pp.81-100.

Walker, D. and Myrick, F. (2006) Grounded theory: An exploration of process and procedure, *Qualitative Health Research,* 16 (4), pp.547-559.

Watson, R.T. and Webster, J. (2020) Analysing the past to prepare for the future: Writing a literature review a roadmap for release 2.0, *Journal of Decision Systems*, 29 (3), pp.129-147.

Wetherell, M., Taylor, S. and Yates, S.J. (2001) *Discourse Theory and Practice: A Reader*. London: SAGE.

Williams, C. (2007) Research Methods, *Journal of Business and Economic Research*, 5 (3), pp.65-72.

Wilson, D.E. (2020) Moving toward democratic-transformational leadership in academic libraries, *Library Management*, 41 (8/9), pp.731-744.

Woodford, I. (2020) *These 19 European startups have pivoted in the face of Coronavirus*. Available from: https://sifted.eu/articles/coronavirus-pivot-startups. [Accessed 24 July 2023].

Wonglimpiyarat, J. (2016) S-curve trajectories of electronic money innovations, *The Journal of High Technology Management Research,* 27 (1), pp.1-9.

Wouters. M., Anderson, J.C. and Kirchberger, M. (2018) New-Technology Startups Seeking Pilot Customers: Crafting a pair of value propositions, *California Management Review*, 60 (4), pp.101-124.

Yukl, G.A. and William, G.L. (2020) *Leadership in Organizations*. 9th ed. Harlow: Pearson.

Zaech, S. and Baldegger, U. (2017) Leadership in start-ups, *International Small Business Journal*, 35 (2), pp.157-177.

Zahra, S.A. (1993) Environment, corporate entrepreneurship, and financial performance: A taxonomic approach. *Journal of Business Venturing*, 8 (4), pp.319–340.

Zhang, X., Liang, L., Tian, G. and Tian, Y. (2020) Heroes or Villians? The Dark Side of Charismatic Leadership and Unethical Pro-organizational Behavior, *International Journal of Environmental Research and Public Health*, 17 (15), pp.1-16.

Appendix

Appendix – I: Key definitions

Technology entrepreneurship is defined as how entrepreneurs assemble resources, technical systems, and strategies to pursue opportunities. It has three phases, namely: formation, exploitation, and renewal (Spiegel and Marxt, 2011).

Ries (2011), Hirvikoski (2014) and Bajwa et al. (2017) identified different types of pivots to test the hypothesis of a company.

1. **Zoom-in pivot:** A single feature becomes an entirely new product.
2. **Zoom-out pivot:** A product becomes a feature of a larger product.
3. **Technology pivot:** Same solution but using different technology.
4. **Platform pivot:** A platform turns into a product or vice versa.
5. **Customer segment pivot:** A change in the target customer segment.
6. **Customer need pivot:** A problem identified by the startup is not crucial for the customer.
7. **Channel pivot:** Another effective way to reach customers.
8. **Market segment pivot:** A segment of the entire market.
9. **Value capture pivot:** A change in the method of capturing value (money).
10. **Engine of growth:** A change in strategy for rapid growth.
11. **Business architecture pivot:** Low volume-high margin or low margin-high volume strategy.
12. **Complete pivot:** Starting a new business.
13. **Side-project pivot:** Side business more successful than main business.
14. **Social pivot:** New team on the same idea.
15. **Partnership pivot:** Two startups entering into a partnership to expand the business and approach more customers.
16. **Brand pivot:** Collapsing multiple brands into one brand and relaunching the same product.

The four stages of the technology S-curve are as follows (Sood and Tellis, 2005):

1. **Introduction stage** – First stage of the technology S-curve where the technology makes slow progress.
2. **Growth stage** – Second stage of technology S-curve where the technology grows rapidly in performance.
3. **Maturity stage** – Third stage of technology S-curve where the technology performance continues but not as in its previous stage.
4. **Decline stage** – Final stage of technology S-curve where the performance of technology declines.

Value proposition is explained as a value that a firm intends to offer to its customers, which in turn explains why customers will prefer one company's product or service Guo et al. (2021) and Ries (2011).

Appendix – II: Research invitation to participants

Research Study on Entrepreneurial Pivoting and the Impact of Technology

Introduction

Entrepreneurship is the process of launching and running a new commercial venture and entrepreneurs are the people who work under uncertainty while exploring new opportunities. Technology entrepreneurship continues to drive economic growth through leveraging new technologies and especially in the era of digitalization. During the entrepreneurial journey, entrepreneurs may change their direction from the original path and thereby pivot. Indeed, pivoting is defined as a structured course of correction by the startup to sustain and grow in the market. Eric Ries[1] explains pivoting in his book called *The Lean Startup*. Therefore, this research study is focused on understanding how high-tech entrepreneurs successfully pivot as part of the entrepreneurial journey. The study also focuses on understanding the role of technology in pivoting.

Research project

Mr Pavan Kumar Sala is researching this topic at the Nathu Puri Institute for Engineering and Enterprise at London South Bank University (LSBU), under the supervision of Professor Simon Philbin and Dr Safia Barkzai. The title of the doctoral research project is as follows: 'Understanding how high-tech entrepreneurs successfully pivot as part of the entrepreneurial journey'. The study will be conducted in the UK on how high-tech entrepreneurs experience pivoting and the impact of technology on the process of pivoting.

Interviews and Case studies

Pavan has already obtained ethical approval from LSBU to conduct the interviews and case studies to support his research study. He is now looking for participants suitable for this research. If you are involved in tech startups in the UK and have experienced pivoting in your entrepreneurial journey, please consider whether you would like to participate in the research study and contact Pavan at the email address below. Interviews and the case studies can be carried out face-to-face or remotely (e.g., via Zoom). All the details collected from participants will be kept confidential and anonymous.

Contact details

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[1] For an introductory summary of 'The Pivot' see: https://www.fastcompany.com/1836238/how-eric-ries-coined-pivot-and-what-your-business-can-learn-it

Appendix – III: Participant information sheet

Study Title

Understanding how high-tech entrepreneur successfully pivot as part of the entrepreneurial journey.

I want to invite you to take part in a research study. Before you decide you should understand why the research is being done and what it would involve for you. Please take time to read the following information carefully. Ask questions if anything you read is not clear or if you would like more information.

What is the purpose of the study?

The purpose of this research study is to investigate how entrepreneurs can pivot (change in direction) as part of their entrepreneurial journey. The research will focus on high-tech entrepreneurs by examining the types of pivots and the factors that cause them to pivot. Thus, the study will investigate the role of technology in pivoting.

Why have you been invited?

While you have been chosen from a pool of appropriately qualified professional people at random, you are a suitably qualified high-tech entrepreneur, which is a prerequisite for our research. Moreover, you undertake this work regularly and have done so for some years. This makes you an ideal candidate to take part in this site-based exercise.

The voluntary nature of participation?

It is up to you to decide. We will describe the study and go through the information sheet, which we will give to you. We will then ask you to sign a consent form to show you agreed to take part. You can withdraw at any time, by informing the researcher the reason for withdrawing. You can notify the researcher via email or telephone. Contact details are available at the end of this form.

What will happen if you take part?

Nothing will happen to you. We will not refer to any participants by name. Participants will be referred to as 'P-1', 'P-2', or a similarly anonymised naming system. We would like you to work in the same way as you would in your regular job. The information you provide will be used to further the research as outlined here, and it is hoped that this will contribute ultimately to improving a high-tech entrepreneur's journey. The method of data collection is through qualitative (interviews). Participants who participate in the interview or the case study will be questioned at least ten questions, and the meeting will be carried out face-to-face or remotely (e.g., via Zoom).

What are the possible disadvantages and risks of taking part?

There is no distinct disadvantage in taking part, nor are there any particular risks, over and above those which may generally be associated with undertaking an online survey or an interview. There are no risks to reputation or associated organisations, as the information you provide will be anonymised for the purpose of our reporting, and your name, nor your employer's name will not be mentioned in any published material. You do, of course, have the right to withdraw from the study at any time.

What are the possible benefits of taking part?

Other than spending the time it takes to answer the survey or interview questions, there will be no notable reward for you, unless you see early access to the research produced afterwards as a reward. We cannot promise that the study will help you. However, the information we obtain from the survey and interview will help to increase the understanding of factors that trigger the pivot, and the role of technology in pivoting, which is aligned with your profession.

Outline data collection and confidentiality?

All information which will be collected during the course of this research will be kept strictly confidential, and all research results will be anonymised. If you withdraw from the study, we will destroy any identifiable samples/recorded interviews, but we will need to use the data collected up to your withdrawal.

What will happen to the results of the research study?

The research study information will be presented in the form of a university thesis. It may also be published in a condensed version, as a paper in a professional or academic journal. You will not be identified in any publication/material personally. All information collected will be anonymised.

Who is organising or funding the research?

The research is funded by Nathu Puri Institute of Engineering and Enterprise (NPI) at the London South Bank University. There are no other external bodies with a financial interest in this work, nor have any offered other resources such as time or materials. For additional information about NPI, please visit

(https://www.lsbu.ac.uk/research/centres-groups/the-nathu-puri-institute#id_first).

Who has reviewed the study?

London South Bank University has approved the research. The research study has been conducted under constant supervision of Prof Simon P Philbin who is the director of the NPI and Dr Safia Barikzai who is an associate professor within the School of Engineering at London South Bank University (LSBU).

Who to contact for further information?

	Researcher details	Supervisor details	Ethics panel
Name	Pavan Kumar Sala	Prof Simon P Philbin	Dr Daqing Chen
Mobile Number	07405766641	-	-
Telephone Number	020708157560	02078157559	02078157492
Email ID	salap@lsbu.ac.uk	philbins@lsbu.ac.uk	chend@lsbu.ac.uk

If you have any other concerns about the way in the research has been conducted, then you can contact Dr Daqing Chen.

If you are happy to participate in the research and contribute your experience for the benefit of research, please sign the consent form.

Thank you for taking the time to read the information sheet and looking forward to meeting you.

Appendix – IV: Participant consent form

Title of project: Understanding how high-tech entrepreneurs successfully pivot as a part of the entrepreneurial journey.

I confirm that I have read and understood the information sheet for the above study and what my anonymous contribution will be.	Yes	No
I have been given the opportunity to ask questions (online survey, face to face, via telephone and e-mail).	Yes	No
I agree that data collected from me will be used for the research study and it may also be published in a condensed anonymous version, as a paper in a professional or academic journal.	Yes	No
I understand that my participation is voluntary and that I can withdraw from the research at any time.	Yes	No
I agree to take part in the above study.	Yes	No

Name of participant:

Signature:

Date:

Name of the researcher: Pavan Kumar Sala

Researcher's email address: salap@lsbu.ac.uk

If you have any concerns about this research that have not been addressed by the researcher, please contact the researcher's supervisor via the contact details below:

Supervisor's name: Prof Simon P Philbin

Supervisor's email address: philbins@lsbu.ac.uk

Appendix – V: Primary thirty interview questions

1. What is your overall professional experience as a tech entrepreneur?
2. How many tech startups have you launched?
3. What is the name of the tech startup you launched?
4. Does your tech startup fall under any of the following technology sectors according to the British Venture Capital Association (BVCA)?

Communication systems	Software technology	Internet technology
Semiconductor technology	Biotechnology, medical, instrumentation and medical pharmaceutical technology	Other electronics related technologies

5. What is the name of technology your startup is based on?
6. Has your startup ever changed direction (pivoted)?
   i) If Yes go to Q5
   ii) If No go to Q15
7. How many times has your tech startup changed direction (pivoted)?
8. How did your tech startup change direction (pivot)?
9. What was/were the factor(s) that caused the pivot?
10. We have discussed types of pivots adopted by your tech startup and the factors that triggered pivoting. Now can you tell me for what factor which type of pivot your startup adopted?
11. Did your tech startup achieve the desired result after pivoting?
12. Once it was decided to pivot, did the startup encounter any challenges trying to go ahead with the pivot?
13. Did initial pivot by your tech startup cause another pivot like domino effect?
14. Do you believe that a tech startup should change its direction to create and sustain its value proposition?
15. A tech startup goes through the following development three phases: Formation (gathering of resources), Exploitation (execution of strategies) and Renewal phase (adapting to customer requirements). Do you think the phase of technology entrepreneurship influences whether to change direction by a tech startup?
    i) If yes, at which phase of technology entrepreneurship, did your tech startup change direction (pivot)?
16. After pivoting did your tech startup change the technology on which it was based?
17. The Technology Life Cycle (TLC) has four main stages: Introduction stage, Growth stage, Maturity stage and Decline stage. Do you think the stage of the technology in the TLC influences whether the tech startup will change direction (pivot)?
    i) At which stage of the TLC, did your tech startup change direction (pivot)?

In case startup did not pivot

1. Do you know the reason why you have not needed to change direction or pivot?
2. Do you think your startup may need to change direction or pivot in the future?
   i) If so, why?
3. A tech startup goes through the following development three phases: Formation (gathering of resources), Exploitation (execution of strategies) and Renewal phase (adapting to customer requirements). Which phase is your company currently at?
4. Do you think the phase of technology entrepreneurship influences whether to change direction by a tech startup?

5. The Technology Life Cycle (TLC) has four main stages: Introduction stage, Growth stage, Maturity stage and Decline stage. Which stage do you think the main technology used in your company is currently at?
6. Do you think the stage of the technology in the TLC influences whether the tech startup will change direction (pivot)?

Appendix – VI: Key definitions for participants (First 30 interviews)

Description of pivots, factors, technology entrepreneurship and technology S-curve shown to interviewees while conducting primary thirty interviews.

British Venture Capital Association (BVCA)

Communication systems
Software technology
Internet technology
Semiconductor technology
Biotechnology, medical, instrumentation and medical pharmaceutical technology
Other electronics related technologies

Types of Pivots

1. **Zoom-in pivot** (a single feature becomes an entirely new product)
2. **Zoom-out pivot** (a product becomes a feature of a larger product)
3. **Technology pivot** (same solution but using different technology)
4. **Platform pivot** (a platform itself turns into a product or vice versa)
5. **Customer segment pivot** (a change in the target customer segment)
6. **Customer need pivot** (a problem identified by the startup is not crucial for the customer)
7. **Channel pivot** (another effective way to reach the customers)
8. **Market segment pivot** (a segment of the entire market)
9. **Value capture pivot** (a change in the method of capturing value (money))
10. **Engine of growth** (a change in strategy for rapid growth)
11. **Business architecture pivot** (low volume-high margin or low margin-high volume strategy)
12. **Complete pivot** (starting new business)
13. **Side-project pivot** (side business more successful than main business)
14. **Social pivot** (new team on the same idea)

Factors

A. Customer feedback (Positive/Negative)
B. Technology challenges
C. Competition
D. Unscalable business
E. Wrong timing
F. Market conditions
G. Influence of investor, partner, or founder
H. Legal issue
I. Flawed business model
J. Side project success
K. Business financials

Table: List of pivots and factors

Types of Pivots	Factors
Zoom-in pivot Zoom-out pivot Technology pivot Platform pivot Customer segment pivot Customer need pivot Channel pivot Market segment pivot Value capture pivot Engine of growth Business architecture pivot Complete pivot Side-project pivot Social pivot	Customer feedback (Positive/Negative) Technology challenges Competition Unscalable business Wrong timing Market conditions Influence of investor, partner or founder Legal issue Flawed business model Side project success Business financials

Technology Entrepreneurship (TE)

Figure: Phases of TE

1. **Formation phase:** The first phase in TE, where the tech entrepreneur assembles resources and technical systems.
2. **Exploitation phase:** The second phase in TE, which involves strategies to exploit the recognised opportunities.
3. **Renewal phase:** The third phase in TE, where the tech startup adapts itself to customer requirements.

Technology S-curve

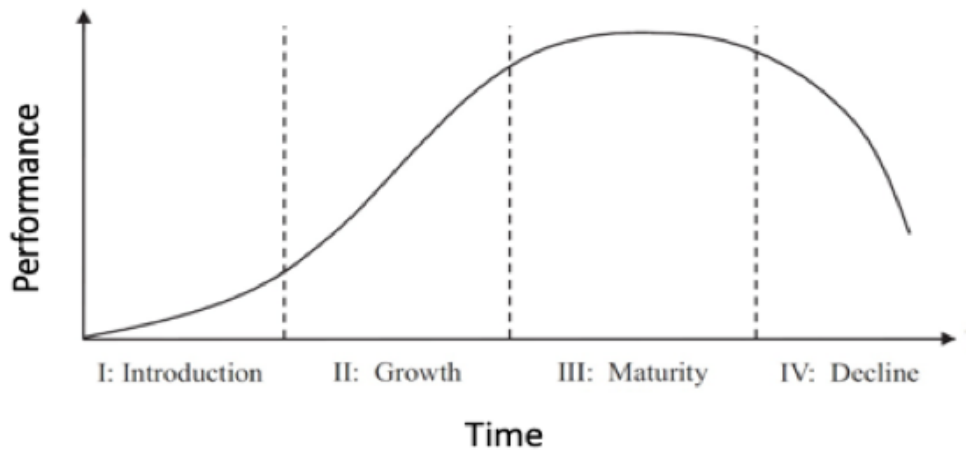

Figure: Four stages of the technology S-curve

1. **Introduction stage** – First stage of the technology life cycle (TLC) where the technology makes slow progress.
2. **Growth stage** – Second stage of TLC where the technology grows rapidly in terms of performance.
3. **Maturity stage** – Third stage of TLC where the technology performance continues but not as its previous stage.
4. **Decline stage** – Final stage of TLC where the performance of technology declines.

Appendix – VII: Longitudinal research invitation to participants

Study on Entrepreneurial Pivoting and the Impact of Technology

Entrepreneurship is the process of launching and running a new business venture and entrepreneurs are the professionals who work under challenging conditions while exploring new opportunities. Technology entrepreneurship continues to drive economic growth through leveraging new technologies, especially in the era of digitalisation. During the entrepreneurial journey, entrepreneurs may change direction from the original path and thereby pivot. Pivoting is defined as a structured course correction by the startup to sustain and grow in the market.

The Nathu Puri Institute for Engineering and Enterprise (NPI) at London South Bank University (LSBU) is conducting a research study, which focuses on investigating how high-tech entrepreneurs successfully pivot during their entrepreneurial journey. We are keen to find out how to improve the survivability of tech-startups and how they can remain competitive by harnessing the latest technologies. In order to understand the experience of the technology entrepreneur, we are conducting longitudinal interviews with tech startups across the UK. We are currently trying to find the tech startups in the UK that are willing to participate in a case study and provide insights into the tech startup's pivoting experience.

The objective of the longitudinal interviews is to identify what are the factors that can trigger a tech startup to pivot and what type of pivot they have adopted to create and sustain the value proposition as well as the impact of technology on pivoting. We are also interested in understanding how companies may have pivoted in response to the current pandemic situation, i.e. how a tech startup has performed its business before, during and after the lockdown period caused by the pandemic.

All information collected in the longitudinal interviews will be used for academic purposes only. The research results will be published in the form of a thesis and academic journal articles. During the entire process, the startup details will be anonymized.

The longitudinal interviews can be carried out remotely (e.g., via Zoom) We assure all participants that the details of the startup, as well as all conversations, will be kept confidential and anonymized following GDPR guidelines and LSBU policies.

Contact details

Pavan Kumar Sala

Doctoral Researcher

Nathu Puri Institute for Engineering and Enterprise

London South Bank University

Email: salap@lsbu.ac.uk

Appendix – VIII: Longitudinal interview questions

Phase-1 interview questions

1. For how long your tech startup is being operational?
2. Has your tech startup ever pivoted before pandemic (before lockdown)?
3. If yes, then how many times your tech startup has pivoted and how did it change the direction(pivoted)?
4. What were the factors that caused the pivot?
5. How do you rate performance of your tech startup during lockdown period on scale of 1 to 5(One being lowest and five is the highest)?
6. During the lockdown, what were the challenges faced by your tech startup in order to survive?
7. Did your tech startup pivot during lockdown to address those challenges?
8. If yes, then how did your tech startup change the direction(pivoted)?
9. If No, then do you know the reason why you have not needed to change direction or pivot?
10. At what phase of technology entrepreneurship was your startup during the lockdown?
11. Before lockdown what was the technology on which your startup was working? At what life stage the technology was, according to TLC?
12. Did your tech startup, change the technology after pivoting?
13. Did initial pivot during lockdown cause another pivot like a domino effect?
14. Did change in direction (pivot) by your tech startup was successful in terms of creating and sustaining its value proposition?

<u>In case startup did not pivot</u>

15. Do you know the reason why you have not needed to change direction or pivot?
16. Do you think your startup may need to change direction or pivot in the future?
17. If so, why?
18. A tech startup goes through the following development three phases: Formation (gathering of resources), Exploitation (execution of strategies) and Renewal phase (adapting to customer requirements).
19. Which development stage is your company currently at?
20. Do you think the phase of technology entrepreneurship influences whether to change direction by a tech startup?
21. The Technology Life Cycle (TLC) has four main stages: Introduction stage, Growth stage, Maturity stage and Decline stage.
22. Which stage do you think the main technology used in your company is currently at?
23. Do you think the stage of the technology in the TLC influences whether the tech startup will change direction (pivot)?

Phase-2 interview questions

1. Explain what is pivoting?
2. While considering pivoting, what is your primary goal as a tech entrepreneur.
    a. To achieve business growth (Finances, Operations, and customer service)
    b. To enhance the quality of product or service
    c. To improve customer engagement (retaining existing customers and acquiring new customers)

    d. Any other (please explain)
3. What is the driving factor for a tech startup to pivot?
4. In the previous interview, you said there is a domino effect in pivoting. Can you explain what type of pivots can be grouped?
   (or)
   In the previous interview, you said there is no domino effect in pivoting. Can you explain why?
5. Do you agree with all the three phases of technology entrepreneurship?
   (If yes)
   Based on your experience, can you explain what type of pivots can be pursued at a particular phase of TE?
   (If no)
   Based on your experience, can you explain the phases that a tech startup goes through? Based on the phases you mentioned just now, can you explain what type of pivots can be pursed for each phase?
6. Being a tech entrepreneur, do you forecast the technology?
   (If yes)
   Which model do you use to forecast the technology?
   (If no)
   Can you explain why it is not necessary to forecast a technology for the tech startup?
7. In the previous interview, you said that there is an influence of technology maturity on pivoting. Can you explain what type of pivots can be pursued at a particular stage of technology?
   (or)
   In the previous interview, you said there is no influence of the technology maturity on pivoting. Can you explain why?
8. During the lockdown, what were the challenges faced by your tech startup to survive?
9. Did your tech startup pivot during lockdown to address those challenges?
   (If yes)
   What type of pivots did your startup pursue?
   (If no)
   Do you know the reason why you have not needed to change direction or pivot?
10. Can a pivot trigger another pivot?
11. Through our preliminary analysis of interviews, we understood that most of the tech startups pivoted when their technology was in introduction stage, including yours. Can you explain why tech startups may prefer to pivot during first stage of technology life cycle?

Phase-3 interview questions

1. There are six major leadership styles and as a tech entrepreneur which type do you follow?
    a. Transformational b) Transactional c) Autocratic d) Charismatic e) Bureaucratic
2. Democratic
3. As a tech entrepreneur, did you ever feel emotionally attached to the original strategy of your startup and resisted the idea of pivoting?
4. Did your company's pivot have any significant impact on the startup's performance?
5. Was it a positive or negative impact?
6. Did your startup face any new challenges since our last meeting?
   (If Yes)

Did your startup pivot to address those challenges?
(If Yes)

7. What type of pivots did your startup pursue?
8. What are the factors that are most important when you introduce new technology?
9. Level of investment in the technology development (in terms of financial or resources committed to the development)
10. Potential culminative sales generated by the products enabled by the technology.
11. Time to introduce the technology.
12. Willingness of the customer to pay for the increased performance provided by the technology.
13. Maturity of the technology (e.g., in terms of introduction, growth and decline etc.).
14. Has the performance of the main technology used to develop your startup's products/services followed an S-shaped curve or not?
15. What is the technology readiness level (TRL of 1-9) of your company's main technology?
16. Do you think the TRL of the technology influences the type of pivot pursued by the company?
17. Is there anything you would like to add to the concept of entrepreneurial pivoting?

Appendix – IX: Key definitions for participants (Longitudinal interviews)

Description of leadership styles, pivots, factors, technology S-curve and technology readiness level (TRL) shown to interviewees while conducting third phase of longitudinal interviews.

Leadership Styles

Transformational: A leader who focuses mainly on developing the overall value systems of the employees, development of moralities, skills, and their motivational level.

Transactional: A leadership style where there is an exchange of targets and rewards between the management and the employees.

Charismatic: A leader who develops a vision and ask followers to follow and execute the vision.

Democratic: The leadership style in which the decision-making is decentralized and is shared by all the subordinates.

Autocratic: A leader who retains decision-making rights and force them to execute the services and strategies according to them.

Bureaucratic: A leader who influences the people under them to follow the policies and procedures.

Startup performance: It comprises financial performance (e.g., turnover, equity owned by an external organisation) and non-financial performance such as no: of employees, market capitalisation and subsidiaries.

Pivots

Zoom-in pivot: A single feature becomes an entirely new product.

Zoom-out pivot: A product becomes a feature of a larger product.

Technology pivot: Same solution but using different technology.

Platform pivot: A platform itself turns into a product or vice versa.

Customer segment pivot: A change in the target customer segment.

Customer need pivot: A problem identified by the startup is not crucial for the customer.

Channel pivot: Another effective way to reach the customers.

Market segment pivot: A segment of the entire market.

Value capture pivot: A change in the method of capturing value (money).

Engine of growth: A change in strategy for rapid growth.

Business architecture pivot: Low volume-high margin or low margin-high volume strategy.

Complete pivot: Starting new business.

Side-project pivot: Side business more successful than main business.

Social pivot: New team on the same idea.

Business ecosystem pivot: Two start-ups entering into a partnership to expand the business and approach more customers.

Brand pivot: Collapsing multiple brands into one brand and relaunching the same product.

Factors

Customer feedback (Positive/Negative)

Technology challenges

Competition

Unscalable business

Wrong timing

Market conditions

Influence of investor, partner, or founder

Legal issue

Flawed business model

Side project success

Business financials

Geopolitical issues

Strategic longevity

Appendix – X: Conversion of qualitative data into quantitative data

Table: Factor vs each pivot category

S. No	Level	F-1	F-2	F-3	F-4	F-5	F-6	F-7	F-8	F-9	F-10	F-11	F-12	F-13	F-14	F-15
1	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
2	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
3	2	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
4	2	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0
5	3	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
6	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
7	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
8	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
9	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
11	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
12	3	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
13	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
14	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
15	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
17	3	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
18	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
19	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
21	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
22	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
23	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.

24	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	2	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
26	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
27	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
28	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
29	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
32	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
33	2	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0
34	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
35	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
36	1	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0
37	2	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0
38	2	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0
39	2	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
40	2	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
41	3	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0
42	3	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
43	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
44	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
45	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
46	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
47	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
48	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
49	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
50	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

51	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
52	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
53	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
54	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
56	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
58	4	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
59	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
60	2	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0
61	2	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0
62	3	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
63	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
64	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
65	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
66	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
67	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	3	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
69	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
70	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
71	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
72	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
74	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
75	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
76	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
77	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0

78	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
79	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
80	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
81	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83	3	1	0	0	0	0	0	1	1	0	1	1	0	0	0	0
84	3	1	0	0	0	0	0	1	1	0	1	1	0	0	0	0
85	3	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0
86	4	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0
87	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
88	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
89	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
90	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
91	2	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
92	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
93	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
94	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
95	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
96	3	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
97	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
98	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
100	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
101	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
102	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
103	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
104	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

105	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
106	3	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0
107	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
108	2	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
109	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
110	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
111	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
112	4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
113	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
114	3	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
115	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
116	2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
117	2	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
118	3	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0
119	3	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
120	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
121	3	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0
122	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
123	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
124	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
125	2	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0
	Total	43	18	32	27	12	14	25	7	10	16	11	2	5	0	1

Note: Product-level pivots are denoted as 1, market-level pivots are denoted as 2, strategy-level pivots are denoted as 3 and team-level pivot is denoted as 4 in the column named 'level'.

Appendix – XI: List of outputs

The research has so far generated three papers, one published in a journal and the other presented at international conferences. A poster presentation was presented at London South Bank PGR Summer School. In addition, guest lectures and a webinar explained the research study findings. Furthermore, two papers are currently under consideration in internationally leading journals.

Journal article

1. Sala, P.K., Philbin, S.P. and Barikzai, S (2022) A qualitative research study of tech start-up journey through entrepreneurial pivoting, *International Journal of Entrepreneurship Behavior and Research*, 28 (4), pp.1050-1074.

Conference proceedings

1. Sala, P.K., Philbin, S.P. and Barikzai, S. (2021) 'Exploring entrepreneurial pivoting and the factors that trigger pivots by tech startups', *IEEE Technology & Engineering Management Conference-Europe (TEMSCON-EUR), Virtual Conference, 17-20 May, 2021,* pp. 1-6.

2. Sala, P.K., Philbin, S. and Barikzai, S. (2020) 'Investigating the Entrepreneurial Pivoting Experience of UK-based Technology Start-ups', *International Society for Professional Innovation Management (ISPIM) Connects Global 2020: Celebrating the World of Innovation-Virtual, 6-8 December, 2020.*

Poster presentation

1. Sala, P. 2019. *Understanding how high-tech entrepreneurs successfully pivot as part of their entrepreneurial journey* [Poster]. Postgraduate Research Summer School Conference, 01-04 July, London South Bank University.

Other presentations

Guest lecture

1. Sala, P. (2023) 'Understanding how high-tech entrepreneurs successfully pivot as part of their entrepreneurial journey' [Lecture], *Technology Evaluation and Commercialisation.* London South Bank University, 29 March.

Webinar

1. Philbin, S., Empson, T., Mansell, P. and Sala, P. 2020. *Enabling Enterprising Engineers* [Webinar]. [Online]. London South Bank University. [Accessed 14 July 2023]. Available from: https://www.youtube.com/watch?v=Q8aZcOpw25Q