

THE ROLE OF TECHNOLOGY PIVOTS IN SOFTWARE STARTUPS: ANTECEDENTS AND CONSEQUENCES

Research paper

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Abstract

Software startups implement and deploy innovative software-based products and services, for which they are in search of a viable and scalable business model. In the well-established Lean Startup Approach, pivoting – testing new fundamental hypotheses about a product, strategy, or engine of growth – is a standard method applied in this process. Failing to pivot at the right time and for the right reasons can substantially jeopardize a startup’s chance to develop into a viable business. Given the alleged importance of pivots, surprisingly little is known about the events leading up to and resulting from pivots. Our study starts to fill this gap in theoretical knowledge by empirically investigating the circumstances under which it is beneficial to perform pivots and what to expect from them for product development, business model development and innovation. Focusing on technology pivots – one specific type of pivot – we use an embedded inductive multi-case research design to propose a preliminary model that identifies three prerequisites, five antecedent and nine consequence categories of technology pivots. Lastly, we discuss the impact of technology pivots on individual business model dimensions.

Keywords: Lean Startup, Technology Pivot, Antecedent, Consequence, Prerequisite, Business Model Impact

1 Introduction

Software startups focus on the implementation and deployment of innovative software-based products and services, for which they are in search of a viable and scalable business model. In the well-established Lean Startup Approach, the standard method applied in this search process involves the performance of a pivot, defined as an adjustment “designed to test a new fundamental hypothesis about the product, strategy, and engine of growth” (Ries, 2011, p. 168). In this research, we focus on one specific type of pivot: *technology pivots* in software startups. In his seminal work, Ries (2011, p. 172) conceptualizes technology pivots as a means to “achiev[ing] the same solution by using a completely different technology”. According to Ries (2011, p. 172), the decision to exercise a technology pivot is driven by the question of “whether the new technology can provide superior price and/or performance compared to existing technology”. Technology pivots are supposedly sustaining innovation, that is, an incremental improvement that does not affect customer segments, value-capture model or channel partners.

Software startups operate in an environment that is typically dynamic, unpredictable, and even chaotic at times (Malhotra, 2000). Throughout their search for a viable and scalable BM, software startups face the challenge of having to define their technological foundation whilst being uncertain about their future BM, and not knowing in which direction individual technologies will develop and what new technologies they will have to compete against (Rosenberg, 2009; Saukkonen et al., 2016). This is unfortunate as the selection of a technological foundation often creates dependencies that are not easy to resolve (Paternoster et al., 2014). Given this highly changeable environment, we argue that the antecedents and consequences of technology pivots may go beyond what Ries (2011) has conceptualized so far. The

existence of further antecedents and consequences has already been discussed in a study by Bajwa et al. (2017) based on secondary data, in which the authors call for primary data studies to extend the existing knowledge base. Additionally, considering the importance of BMs for software startups in building viable businesses, we argue that it is worthwhile to determine the impact of technology pivots on BMs to allow for informed decision making towards technology pivots. Although technology is crucial for software startups, and their innovative products and services have a substantial impact on the global economy, surprisingly little effort has been made to theorize the role of technology in shaping entrepreneurial opportunities, actions, and outcomes (Nambisan, 2017). To the best of our knowledge, no empirical study has so far focused and elaborated on the antecedents and consequences of technology pivots, or on their impact on BMs. Hence, we pose the following research questions:

RQ1: What are the antecedents and consequences of technology pivots in software startups?

RQ2: What is the impact of technology pivots on the business models of software startups?

In the absence of a sound theoretical basis that can be used to answer this question, we conduct a qualitative research approach as a multiple-case study design. The findings are presented in the form of a preliminary theoretical model consisting of antecedent and consequence categories. By so doing, this study provides empirical evidence for the interdependencies between technology, BM development and innovation in software startups (Foss and Saebi, 2017). Also, the observed consequences are used to derive the BM impact of technology pivots applying the V⁴ ontological structure of BMs by Al-Debei and Avison (2010).

2 Background

2.1 Software Startups

In order to understand the concept of pivots and their importance for many startups on their trajectory of growing into viable businesses (i.e. reaching long-term survival and sustained profits), we need to first understand what characterizes startups. Startups are new organizations with no operational history which provide innovative products and services, searching for a “[...] scalable, repeatable, [and] profitable business model” (Blank and Dorf, 2012, p. xvii). They frequently operate in highly volatile markets and try to “[...] solve a problem where the solution isn’t well known” (Giardino et al., 2014, p. 28). This means that startups are by their nature embedded in extreme uncertainty with regards to their main business hypotheses, which they continuously need to test and validate (Terho et al., 2015). In the context of this study, a software startup focuses mainly on the implementation and deployment of innovative software-based products and services (Nguyen-Duc et al., 2015). As a result of the rapid advances in information technology and the software industry, they often have to act in environments that are unpredictable and experience frequent technological transformations (Wang et al., 2016).

2.2 Business Models

A BM describes “[...] how a firm organizes itself to create and distribute value in a profitable manner” (Baden-Fuller and Morgan, 2010, p. 157), by “outlin[ing] the architecture of revenues, costs, and profits associated with the business enterprise delivering that value” (Teece, 2010, p. 173). This means that a BM is used as a role model or short description of a business’s organization and also describes the workings inside the firm and its relations to outside elements (Baden-Fuller and Mangematin, 2013). Without a well-defined BM, startups fail to capture the value created by the applied technological innovation. Yet, startups that have identified viable and scalable BMs, regularly also need to iterate their existing BMs because of evolving technologies, network positions, emerging competition, or changing customer demands (Foss and Saebi, 2017; Teece, 2010). This process is called business model innovation (BMI). Using BMI, startups react to “major and unpredictable changes in the business environment” (Voelpel et al., 2004, p. 264), which then leads to the “discovery of a fundamentally different BM in an existing business” (Markides, 2006, p. 20). BMI “thereby aims at consciously renewing a firm’s core business logic” (Schneider and Spieth, 2013, p. 4).

The literature offers a number of conceptualizations of BMs, each of which features a distinct set of dimensions and components (Baden-Fuller and Morgan, 2010; Burkhart et al., 2011; Krumeich et al., 2012). These components help to make the abstract concept of BMs more tangible and enable their initial development and later innovation. In addition, a variety of visualisation languages and approaches have been developed to represent BMs (John et al., 2017) with the aim to facilitate understanding, analysis, and innovation. One well-known conceptualization and visualisation for BMs is the V⁴ ontological structure by Al-Debei and Avison (2010), which consists of four dimensions to which 16 individual components are assigned. The value proposition dimension includes the products or services on offer, the intended value to be created, the respective value elements incorporated within the offering, as well as the targeted market segments. Second, the value architecture dimension focuses on the core-resources used by an organization for value configuration, including aspects such as technological architecture and organizational infrastructure, as well as the core-competencies required. Third, the value network dimension emphasizes the involvement of internal and external parties, such as employees, partners and other stakeholders in an organization and refers to the collaboration among them and their coordination. It also covers how value is being exchanged and delivered through channels. Finally, the value finance dimension consists of costing, pricing, and the respective revenue structure of a BM.

2.3 Lean Startup and Pivot

The Lean Startup approach encourages startups in environments of high uncertainty to develop their products and services iteratively (Blank and Dorf, 2012; Ries, 2011). The approach aims to maximize learning while keeping the resource investment efficient. One method is validated learning, which involves business hypotheses being tested and measured in order to validate effects and assumptions. To significantly change the development path based on validated learning startups often undertake pivots (Blank and Dorf, 2012; Ries, 2011). Pivots are “structured course corrections designed to test a new fundamental hypothesis about the product, business model, and engine of growth” (Ries, 2011, p. 178). Through fast iterations and “by reducing the time between pivots, it is possible to increase the odds of success” (Bosch et al., 2013, p. 5). However, Ries (2011, p. 178) also states that the “decision to pivot is so difficult that many companies fail to make it”. He presents ten different types of pivot that can appear in startups (cf. Table 1). According to Ries’ conceptualization (2011, p. 178), technology pivots help to “achieve the same solution by using a completely different technology”, in order to improve performance or reduce costs. Yet, this conceptualization requires systematic and scientific validation.

Looking at existing research on the subject of software startups and pivots, Unterkalmsteiner et al. (2016), in their research agenda on software startups, describe the existing research base as nascent, and pivoting as particularly important for software startups since they are “prone to the rapidly changing technology” (Unterkalmsteiner et al., 2016, p. 100). They call for “building a fundamental framework on reasons for pivoting and their types”. Furthermore, they stress the importance of better understanding the pivoting process in software startups and methods used for the pivoting decision. Nguyen-Duc et al. (2015) highlight the increasing importance of software startups for the creation and innovation of products and services. Throughout their analysis, they observe pivoting as a means of course correction and underline its importance as a key activity. Terho et al. (2015) focus their research efforts primarily on pivots in software startups. Their study is motivated by the argument that the main hypotheses about BMs must be continuously tested and improved. Throughout this process, pivoting is an important means for course corrections. They analyse three software startup case studies consisting of 14 pivots in total. Among their cases, however, only one technology pivot was analysed, which “was made to enlarge the scope of the product” (Terho et al., 2015, p. 564). It led to changes in the customer segment and cost structure components, indicating that performance increases and cost reductions, highlighted by Ries (2011), are far from the only decision motivations and effects of pivoting. Bajwa et al. (2016) focus on the antecedents for pivots and observable pivot types in software startups using a multi-case study approach. They obtained data from four software startups about ten pivot instances and five different types of pivot. The findings show that software startups perform different types of pivots in response to business and technology issues during their product development life cycle. They identified

two new pivot types (team and complete pivots, see Table 1) in addition to the ones suggested by Ries (2011). They also show the potential links between the observed pivots.

Pivot type	Description	Listed in				Instances analysed by		
		Ries (2011)	Terho et al. (2015)	Bajwa et al. (2016)	Bajwa et al. (2017)	Terho et al. (2015)	Bajwa et al. (2016)	Bajwa et al. (2017)
Zoom-In	A single feature becomes the whole product	✓	✓	✓	✓*	2x		7x
Zoom-Out	Whole product becomes a single feature of a much larger product	✓	✓	✓	✓	4x		2x
Customer Segment	Change of targeted customer segments	✓	✓	✓	✓	2x	2x	6x
Customer Need	Other customer need targeted / satisfied	✓	✓	✓	✓		1x	17x
Platform	Change from application to platform and vice versa	✓	✓	✓	✓	1x		3x
Business Architecture	A switch from high margin, low volume to low margin, high volume	✓	✓	✓	✓	2x		
Value Capture	Changes to the way how value is captured	✓	✓	✓	✓	1x		
Engine of Growth	Changes in strategy to seek faster growth	✓	✓	✓	✓			
Channel	Switch to channels with better effectiveness	✓	✓	✓	✓	1x		1x
Technology	Replacing existing technology with different technology	✓	✓	✓	✓*	1x	2x	5x
Team	Changes of key members (e.g. co-founder) or development of completely new team			✓			2x	
Complete	All aspects are changed, only the original entrepreneurial team remains			✓	✓		2x	11x
Market Zoom-In	Narrow down target market from a broader market to a more specific market segment				✓			1x
Side Project	A side-project becomes the main business idea				✓			2x

Table 1. List of identified pivot types and research performed on them (* identified as major product related pivots)

In three of their four case studies, one pivot triggered a succeeding pivot. Concerning the two observed technology pivots, they identified emerging IT-innovation and technological complications as the antecedents for their performance. In a subsequent study of 55 pivots in software startups (such as PayPal, Slack, and Yelp), Bajwa et al. (2017) identified observable pivot types in software startups, based on a larger set of secondary data. In addition to the ten pivot types suggested by Ries (2011), two new pivot types (market zoom-in and side project pivots) were identified along with 14 antecedents that led to the observed pivots being performed (Bajwa et al., 2017, p. 2373). As the two-major product related pivots, technology pivots and zoom-in pivots were identified, highlighting their respective importance. For the three technology pivots analysed in their study, the antecedents were described as either “technology challenges” or “wrong timing” (Bajwa et al., 2017, p. 2392). Subsequently, Bajwa et al. (2017) call for primary data studies to extend the existing knowledge base on pivots. Yet, despite the acknowledged difficulty concerning the decision to pivot and the assumed importance of pivots for the development of software startups to become viable businesses, little theoretical and empirical knowledge exists about which antecedents lead up to technology pivots and what consequences result from them. This is especially surprising as Giardino et al. (2015, p. 56) found that “thriving under technological uncertainty” is the number one challenge in software startups. Consequently, we argue that an empirically grounded understanding of the antecedents and consequences of pivots can lead to theory development explaining the circumstances under which it is beneficial to perform technology pivots and what to expect from them for product and BM development or BMI.

3 Method

The phenomenon of pivots is a relatively new field of research (Bajwa et al., 2017; Terho et al., 2015). To understand the antecedents and consequences of technology pivots in software startups, a qualitative research approach is chosen. Our study applies an embedded inductive multi-case study research design,

according to Yin (2009). This type of method is suitable in a research context where it is central to ask open-ended questions to gain a deep understanding of the subject. It allows to study the antecedents and consequences in-depth and compare findings across software startups to increase the external validity of the results (Yin, 2009). Also, it supports the derivation of the impact of the observed consequences on the BM. In a first step, a case study protocol and database were created.

3.1 Selection of the Case Studies

As we seek to explore the broad variety of antecedents underpinning the technology pivots performed in software startups and their impact on BMs, we selected software startups with B2C- and B2B-BM applying a theoretical sampling approach. A software startup was eligible as a case study participant when it performed a structured course correction to core technology parts, based on the definition by Ries (2011). The cases were selected to achieve theoretical replication (Yin, 2009), with the aim of increasing the variance of antecedences and consequences of technology pivots (Bhattacharjee, 2012).

3.2 Data Collection¹

For our data sources we chose existing documents and supplemented these with interviews. First, we collected publicly available documents (e.g. press releases and presentations published on YouTube). To fully understand the nature of technology pivots, semi-structured interviews were conducted with senior management of software startups (i.e., co-founders and senior managers (employed for more than 2 years)) who had made the decision to perform a technology pivot. As such they had first-hand experience of the consequences that resulted from the technology pivot and its impact on their BM. The interviews were conducted in the interviewees' native language (German) with the exception of one which was conducted in English. The represented startups came from different focus industries (e.g. commerce, education, and entertainment). We further collected internal presentations provided by the interviewees. In total, we conducted 14 interviews covering 20 instances of technology pivots (cf. Table 2), at which point we reached theoretical saturation. We assigned pivot instances to four life-cycle stages according to Kazanjian (1988), i.e., (1) Concept & Development, (2) Commercialisation, (3) Growth, and (4) Stability. The interviews covered four question blocks: (1) company growth path, (2) key (technological) pivot points, (3) antecedents for technology pivots, and (4) consequences observed after technology pivots. The last part also covered questions related to the observed BM impact. The interviews had an average length of 39 min (median 40 min) and were transcribed in full (about 79,000 words).

3.3 Data Analysis

The data analysis was performed according to Yin (2009), based on the transcripts of semi-structured interviews and case-specific documents. An iterative approach to the data analysis and theory building using open, axial, and selective coding was chosen (Corbin and Strauss, 1990). First, the interview transcripts and case-specific documents were openly coded. This involved attaching descriptive labels to interview statements, case-specific documents and the recorded presentations, and resulted in 375 initial codes, then the properties and dimensions of each concept were refined based on the constant comparison technique (Charmaz, 2006; Corbin and Strauss, 1990). The coding was done in Atlas.ti 8. During axial coding, connections were established between codes and categories based on the open coding and related to each other (Corbin and Strauss, 1990). Core-concepts were identified to create explanations of the phenomena. We identified antecedents, which we conceptualize as the main motivations, and explanations that lead up to the exercise of technology pivots. Similarly, we identified consequences, i.e. the observed effects and results after a technology pivot had been exercised. We systematically compared antecedents and consequences within and across cases using replication logic. In a cross-validation process with two academic colleagues, the core-concepts were iteratively refined in two sep-

¹ A related paper by Bohn and Kundisch (2018) draws on the same research environment. Despite an overlap in the underlying dataset, the related study differs considerably in size and scope including the covered research questions.

arate one hour workshops, to increase their robustness and reliability (Yin, 2009). During selective coding, the main categories were identified and linked to core-concepts. To triangulate and enrich the interviews, case-specific documents consisting of internal presentations and public announcements (n = 9) as well as recorded public presentations (n = 4) were used. At this stage, we were also able to derive the observed BM impact. We used pattern matching as the analysis technique (Yin, 2009). This final step of theory building resulted in a preliminary theoretical model.

Name	Year est.	Type	No of Empl.	Interviewee	Description of Technology Pivot(s)	Life-Cycle Stage
ST0	2008	B2C	450	CEO*	(1) Replaced the core frontend framework of their SaaS product. (2) Shifted their focus to a mobile, instead of a desktop-based product.	Commercialis. Growth
ST1	2009	B2C	270	VP Tech.	(1) Replaced their desktop-based product with a mobile-based product. (2) Replaced native mobile development with a cross-platform engine.	Growth Stability
ST2	2010	B2C	100	CEO*	(1) Introduction of CRM system that includes core business logic. (2) Replacement of CRM system with self-made solution.	Growth Growth
ST3	2012	B2C	250	CTO	(1) Enhanced their core business logic with machine learning solution.	Stability
ST4	2013	B2C	20	CEO*	(1) Shifted their focus to a mobile, instead of a desktop-based product.	Growth
ST5	2014	B2C	40	CTO*	(1) Relocated extensive frontend logic into backend services. (2) Replaced the database and data storage logic of their SaaS product. (3) Replaced their mobile development framework.	Growth Growth Growth
ST6	2015	B2B	15	CEO*	(1) Replaced automation framework with a semi-manual approach.	Growth
ST7	2005	B2B	50	CTO*	(1) Replaced their client-server-architecture with a SaaS solution.	Concept. & Dev.
ST8	2009	B2B	20	Lead Dev.	(1) Replaced their monolithic system architecture with micro-services.	Growth
ST9	2012	B2B	10	CEO*	(1) Replaced their architecture for data storage and data provisioning.	Commercialis.
ST10	2014	B2B	12	CTO*	(1) Introduced a container-based architecture. (2) Replaced the core frontend framework of their SaaS product.	Commercialis. Commercialis.
ST11	2015	B2B	5	CTO*	(1) Abandoned their mobile-based solution and created a BaaS-solution.	Commercialis.
ST12	2015	B2B	15	CEO*	(1) Replaced the core frontend framework of their SaaS product.	Concept. & Dev.
ST13	2015	B2B	5	CEO*	(1) Replaced their web-app solution with a mobile-based solution.	Commercialis.

Table 2. Overview of Case Study Participants (* Co-founder of Startup)

4 Findings

With regards to RQ1, based on the identified antecedents and consequences of technology pivots, a preliminary theoretical model was created (cf. Figure 1, Sections 4.1 – 4.5). A detailed version including its underlying core concepts is provided as an online resource (<https://goo.gl/wpZonM>). The two antecedent categories shaded in grey were previously conceptualized by Ries (2011). The model also shows

the three identified prerequisites preceding the performance of technology pivots. Furthermore, complications in the respective business environments were described. The identified technology pivot types are explained thereafter.

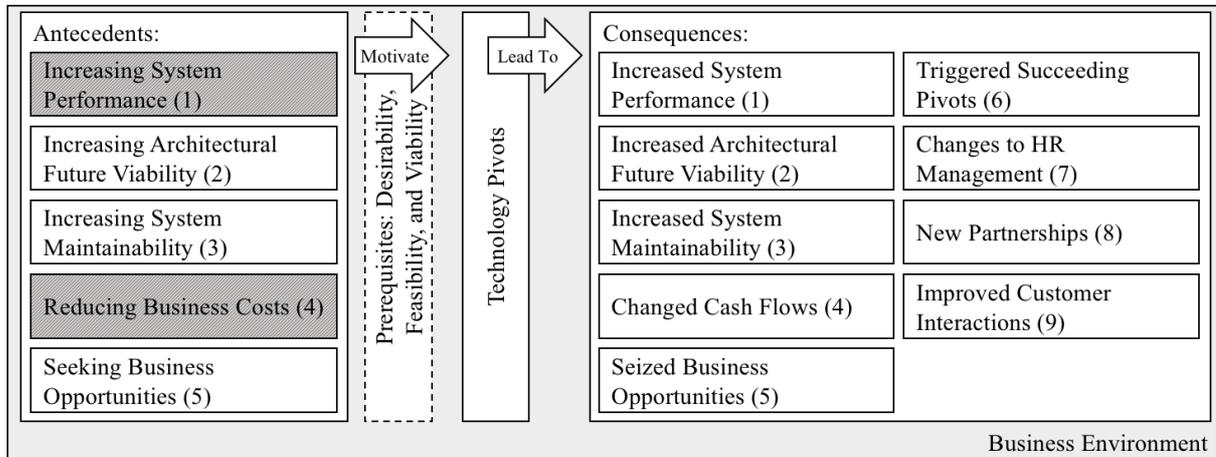


Figure 1. Preliminary Model of Antecedents and Consequences of Technology Pivots

With regards to RQ2, the impact of technology pivots on BMs was analysed and derived from the observed consequences, which we assigned to the dimensions of the V⁴ ontological structure of BMs by Al-Debei and Avison (2010) (cf. Figure 2, Section 4.6).

4.1 Antecedents of Technology Pivots

The identified antecedents of technology pivots were grouped into five distinct categories. The first three categories (1-3) relate to the technology level, while the two remaining focus on financial (4) or strategic aspects (5). It was found that technology pivots are motivated by single or multiple antecedents.

Increasing System Performance (1). For software products, system performance (IEEE, 1990) is an essential quality attribute (Kekre and Krishnan, 1995). Depending on the chosen technology stack and implementation approach, performance can fluctuate quite substantially. Several study participants experienced this issue, which motivated them to exercise technology pivots (“a powerful impetus was reaching performance limits” (ST12²). The resulting fluctuation in system performance led to negative customer feedback, which further motivated the study participants to increase their system performance (“We received feedback that our system was unstable and slow to respond” (ST9)). Performance considerations included stability and resolving issues customers experienced from bugs. In other cases (ST5 and ST10), limited system performance constrained the implementation of new functionality. The fact that system performance issues can result in technology pivots being exercised was also observed in case studies by Bajwa et al. (2016) and Bajwa et al. (2017), and confirmed in our study.

Increasing Architectural Future Viability (2). Some study participants were concerned about the future viability of their architectural design (IEEE, 1990). First, this was expressed through the pursuit of increasing internal software quality (ST12), as well as by applying technological standards as soon as they emerged (ST7). ST10 added that when they saw that a technology “represents what people will use in the future” it made sense for them to pivot in this direction. Second, future viability was pursued by avoiding technological obsolescence of internal systems, through pivoting to more viable options (ST0 and ST1). Third, choice errors made earlier in the implementation and system architecture were adjusted through technology pivots, which further increased future viability (ST 5). Fourth, when internally developed solutions “could not compete with external solutions for the required business value which was needed very close in time” (ST10), motivation to exercise a technology pivot increased.

² All quotes were translated by the authors for interviews not conducted in English.

Increasing System Maintainability (3). Due to the nature of software startups, where decisions are made frequently and fast, implementation can be sub-optimal. As a result, system maintainability (IEEE, 1990) can become a pressing issue. Some study participants reached a point where their systems became difficult to maintain internally. The reasons for this were manifold. First, the codebase was undocumented and had grown considerably quickly (ST7). Second, the architecture had reached such complexity that it became increasingly hard to grasp ("the software was already really difficult to start with and now you could hardly find your way around it" (ST8)). This led to a situation where "considerable bottlenecks emerged. There were [only] a few people who knew the implementation inside out" (ST8)). Third, new staff needed considerable time to be inducted, and functionality was not verifiable, which led to unexpected system behaviours (ST10). In order to increase the manageability of their architectural design, complexity reductions were frequently desired, and "it became clear to us that the fewer technologies we are using, the better" (ST0). Through complexity reduction, they attempted to reduce knowledge silos and to increase their team's overall understanding of the systems (ST8 and ST9).

Reducing Business Costs (4). For software startups with little to no profits, business costs are challenging ("You always have to consider carefully how you can realize things in order to reduce costs" (ST5)). Business costs include both fixed and variable development and operational costs. For ST9, due to their implementation approach, the operational costs rose to a level equal to their revenues, making a technology pivot inevitable. For ST10, the high level of development costs hindered any further business growth. In order to account for a high level of business costs, the study participants (e.g., ST2, ST6, and ST7) performed technology pivots by either implementing 3rd party solutions, which reduced internal development efforts, or by developing enhanced home-made solutions, reviewing their product's needs.

Seeking Business Opportunities (5). As a result of the flexibility of their products and internal agility, seeking new business opportunities is not uncommon for software startups (Bajwa et al., 2017). Business opportunity recognition describes the "alertness to changed conditions or to overlooked possibilities" (Kirzner, 1985). ST0 stated "we see ourselves as a growth-company, and we expected this technology to become a massive topic, that's why we wanted to be part of this opportunity right from the beginning". It was observed that strategy changes, caused by business opportunities becoming available through emerging IT-innovation, can go hand-in-hand with subsequently necessary technology pivots being exercised (ST0, ST1, and ST3). This was also observed for one case study by Bajwa et al. (2016). In other cases, as a result of validated learning through the Lean Startup approach, the study participants changed their targeted customer segments (i.e., exercise of a *customer-segment pivot*). This made it necessary to exercise a subsequent technology pivot to reach the new customer segments (ST11 and ST13).

4.2 Prerequisites for Technology Pivots

Our findings indicate that – in general – three prerequisites need to be fulfilled before a technology pivot should be performed: (1) desirability, (2) feasibility, and (3) viability (Fitzsimmons and Douglas, 2011; Pant et al., 2017). As a first threshold, there need to be sufficient antecedents which confirm the desirability of a technology pivot (mentioned by all study participants). Subsequently, feasibility (mentioned by e.g., ST1, ST6, ST12) and viability (mentioned by e.g., ST0, ST4, ST10) are validated. Feasibility describes the skill and knowledge-based ability to implement technological changes, for which proof-of-concepts were utilized. Viability describes the possibility to successfully perform a pivot based on prevailing resources (e.g., HR, time, and money) and circumstances (e.g., roadmap). Participants estimated the required resources and made changes to the roadmap before performing technology pivots.

4.3 Consequences of Technology Pivots

The identified consequences of technology pivots were grouped into nine distinct categories. The first three cover the technology level (1-3) and could be directly related to the following antecedent categories: increasing system performance, future viability, and maintainability. The subsequent two categories (4-5) appertained to reducing business costs and seeking business opportunities, respectively. However, the observed effects are ambiguous. The latter four consequence categories (6-9) affect different aspects of the business and were not assignable directly to any antecedent categories.

Increased System Performance (1). Study participants who aimed for an increase in system performance stated that performance goals had been reached (e.g., ST1, ST2, ST4, ST5, and ST9). ST9 stated “customers were receiving their request results within milliseconds, which was a massive performance increase” and ST5 said that “the improved performance was immediately visible to the customer”. In retrospect, ST1 stated that “the change, especially when looking back over the last years, certainly had a positive impact on performance”. Improved performance aspects mentioned included stability, response time, computation power, and resulted in an improved user experience and the reduction of negative customer feedback. Subsequently, the perceived product quality had considerably improved.

Increased Architectural Future Viability (2). The study participants perceived an increase in future viability for two reasons. First, the new architectural design supported the long-term product vision (ST1, ST4, ST5, and ST9). ST9 stated that “we always considered our long-term vision and which technology stack would be needed for it” and how to “get from Minimal-Viable-Product to that long-term vision”. Second, the new system architecture appeared to provide long-term future manageability (ST0 and ST3).

Increased System Maintainability (3). Study participants perceived that technology pivots had a direct impact on the software development efficiency within their business (e.g., ST1, ST2, ST8, and ST11). As stated by ST11, “the whole implementation process is a lot faster”. Moreover, it increased system as well as code maintainability (“we gained more control about what happens to the end-user” (ST8)). Also, additional functionality became implementable through the opportunities of the new technology (“we can now implement functionality, which we could not do before, which makes our customers happy” (ST8)). Through an increased system maintainability, the perceived product quality increased.

Changed Cash Flows (4). In contrast to the obvious motivation to reduce costs (cf. Section 4.1), the actual consequences on cash flows are ambiguous. Both the cost structure and revenue streams were affected by technology pivots. While in some cases (e.g. ST5, ST9, and ST11) operational and developmental costs were reduced, in other cases, these and other costs increased (e.g. ST0 and ST1). ST5 managed to “reduce deployment times from hours to seconds, which implied drastically lower costs of change”. However, for ST1 business costs increased because of additionally required HR (“we needed special experts with new engineering skills” (ST1)) and licenses. While technology pivots generally led to increased revenues, ST0 and ST1 had to pay out shares of their revenues to their new key partners (“we implemented a revenue-share-deal” (ST0)) and received their revenues through them.

Seized Business Opportunities (5). Through technology pivots, study participants were enabled to validate further BM hypotheses (e.g., ST0, ST1, ST4, and ST13). ST4 described that “new configurations of our business model became easier to validate”. In this context, new business opportunities were enabled and utilized through technology pivots; as stated by ST1 “there was a massive spirit of optimism in this new market. During our launch, the growth potential became visible very quickly”.

Triggered Succeeding Pivots (6). The changes introduced through technology pivots triggered the necessity or desirability of additional pivots of different types (Terho et al., 2015). For example, focussing on new customer segments resulted in a subsequent *customer-segment pivot* (ST0, ST1, ST7, and ST11), at times surprised study participants (“It was a bit of a surprise that we reached them” (ST7)).

Changes to HR Management (7). Study participants reported a change in HR management in three ways. First, they adapted their HR requirements in terms of number of employees, skills, and expert knowledge (“we had a much bigger team before [the pivot]” (ST11)) ST4 stated that they “hired more engineers for new specialized tasks”. Through the newly required skills, it became necessary for existing employees to acquire new knowledge (“a critical problem was that engineers did not know the new technology yet. Thus, they needed to invest time to learn it” (ST11); „We have retrained employees [for the new skills] or they retrained themselves” (ST1)). Second, with regards to hiring opportunities, it was stated that “[for the new technology] it is a lot easier to find engineers” (ST8). As a result of a better technological foundation, new employees were able to “get started a lot faster” (ST8). Third, study participants noted greater employee satisfaction as a result of less complexity and better manageability; as stated by ST10 “our employees fed back that work is a lot more fun now”, because “stability increased”, “you know where to make the right changes” and “you are less scared to break things”.

New Partnerships (8). As part of performing technology pivots, our study participants established new partnerships and collaborations. These could be active, newly established partnership contracts, or passive, through engagement with the open source community. As stated by ST0, “suddenly, we had new partnerships that needed to be managed”. These partnerships then required time (“you need to make time for your partners and they need to make time for you” (ST1)). This required an unexpected effort for the study participants. Through new partnerships, “new dependencies were created” (ST6) that could not easily be resolved. ST1 stated that “it would be possible to do a technological switch to resolve the partnership but it would be difficult to do this from one day to the next”. Also, collaborations with the open source community were established by “publishing parts of our product as open source” (ST10).

Improved Customer Interactions (9). We found that technology pivots resulted in improved customer interactions changes in two ways. First, new distribution channels became available and were added to the BM (“the Appstore was super exciting for us because it was a new channel that allowed us to grow more easily” (ST1)). Second, the way the study participants interacted with their customers changed. In regards to their new SaaS BM, ST7 stated that, “the amount of self-service is much higher” and ST1 that their customer communication was moved to a new CRM tool that became necessary.

4.4 Business Environment Complications

Within the internal business environments in which technology pivots are performed, we observed three complications. First, we found that performing technology pivots can lead to an increased friction between stakeholders (e.g., between management and employees). This results from disagreements about the necessity of technology pivots and frustration while performing them. “The consequence we saw internally was a high level of frustration” (ST6) as “there were a lot of discussions in which direction we are going” (ST11). This then resulted in “losing momentum as a team [...] that you need to rebuild” (ST11). This increase in friction was not anticipated by the study participants who performed their first pivot. Second, performing technology pivots creates considerable management overheads on the project at a people management as well as on a technical level. For the case of ST1, “it meant that we had to implement workarounds [...] that cost time and money and where not visible to the customer”. Third, the completion of technology pivots often took more time than expected (“We underestimated the complexity and how long we will end up working on it until it works” (ST4)).

4.5 Types of Technology Pivots

As shown in previous studies (Bajwa et al., 2016; Bajwa et al., 2017), the pivot types listed by Ries (2011) might not represent an exhaustive list of all pivot types and initial findings indicate the existence of further types (cf. Section 2.3). Since the study participants in our research performed technology pivots for a diverse set of antecedents, we tried to analyse as to whether it is possible to derive sub-types of technology pivots as a next step. We consider this step to be important, since it allows a better classification and enhances the understanding of individual technology pivot cases by researchers as well as practitioners. Thus, we asked, are the observed technology pivots divisible into sub-types? To answer this question, we further analysed the antecedents of the technology pivots. First, we assigned the antecedent categories into groups based on their overarching motivations. This enabled us to identify two distinct groups. The first group represents the antecedent categories that are driven by an urgent necessity (i.e. increasing system performance, architectural future viability, or system maintainability, and reducing business costs), characterized through complications and pressure points that need to be resolved (e.g., low system performance, complicated code architecture, and high business costs). The second group represents the antecedent category that is motivated by an emerging business opportunity and is entirely opportunistically driven (i.e. seeking business opportunities). Second, we differentiated the antecedents for each instance of a technology pivot into major and minor with regards to their importance during the decision process. Third, we analysed the technology pivots in terms of their major antecedents and the previously specified two identified antecedent groups to assign a technology pivot type. We observed that 13 technology pivots were largely motivated by necessity (e.g., “the driving factors were clearly that our systems were not scalable, stable and were too expensive” (ST9)) and five pivots were mainly motivated by a business opportunity (e.g., “the probability that the mobile ecosystem

would lead to enormous growth rates was foreseeable and very likely” (ST1)). Subsequently, we named the identified two technology pivot types as (1) ‘necessary’ technology pivot and (2) ‘opportunistic’ technology pivot (cf. Table 3). Two observed pivots (ST10 2nd pivot and ST11) showed major antecedents of both groups and were thus not clearly assignable to either, rather, they represent a mixed type.

Name	Pivot No.	Antecedents					Derived Technology Pivot Type	
		Group 1			Group 2		Necessary Technology Pivot	Opportunistic Technology Pivot
		Increasing System Performance	Increasing Architectural Future Viability	Increasing System Maintainability	Reducing Business Costs	Seeking Business Opportunities		
ST0	1	○	○				●	
	2		○				●	
ST1	1		○				●	
	2	○	●	●	○			●
ST2	1	○		●				
	2	●	○	●				
ST3	1		○				●	
ST4	1	●	●				○	
ST5	1	●			○			
	2	●						
	3		●	●				
ST6	1	●	○		○			
ST7	1	○	●	●	○			
ST8	1	○	○	●				
ST9	1	●	○	○	●			
ST10	1	●	○	○				
	2	○	●	○	●		●	
ST11	1		●	○	○		●	
ST12	1	●	○	●				
ST13	1	○					●	

→

Derived Technology Pivot Type	
Necessary Technology Pivot	Opportunistic Technology Pivot
	✓
	✓
	✓
✓	
✓	
✓	
	✓
✓	
✓	
✓	
✓	
✓	
✓	
✓	
✓	
✓	
✓	
-	-
-	-
✓	
	✓

Table 3. Differentiation of Technology Pivot Types based on Antecedents per Case Study (● major antecedent, ○ minor antecedent; ✓ technology pivot type; - not derivable)

4.6 Business Model Impact of Technology Pivots

Pivots help startups to perform structured course corrections, to react to environmental changes and to modify their BMs so that they are aligned with their business strategy (Foss and Saebi, 2017; Teece, 2010). Yet, the impact of technology pivots on BMs has not been scrutinized, which means it is unclear how BMs are being impacted. A clear assignment of the observed consequences to BM dimensions is important as software startups do not want to rely on ambiguity and wrong evaluations of their technology pivot’s impact on their BM before making the crucial decision to perform a technology pivot (Magretta, 2002). An empirically based theoretical understanding of the impact of technology pivots on BMs can serve as the basis for further studies theory development which can then lead to theory generation. As a first step, we aim to identify how BMs are influenced through technology pivots by analysing the impact of the observed consequences on individual BM dimensions. For this, we apply the well-known V⁴ ontological structure of BMs (cf. Section 2.1) by Al-Debei and Avison (2010). We assigned the 9 identified consequences of technology pivots (cf. Figure 1) to the respective dimensions of the V⁴ ontological structure of BMs where we observed strong thematic overlaps between the descriptions by Al-Debei and Avison (2010) and our case study data analysis (cf. Figure 2). For the value proposition dimension, the strongest thematical overlap was in “seized business opportunities”. When a technology pivot was motivated by seizing a business opportunity, its influence was described as significant on the value proposition of the product or service on offer. The value proposition influence was observable e.g., through new IT-innovations being utilized, changing the value created for the end-users. Furthermore, the “succeeding pivots” triggered (e.g. changes in customer segments) had their main impact on changes to targeted market segments, which is part of the value proposition dimension. With regards to

the value architecture dimension, we found that it was positively impacted through an “increase in system performance”, an “increase of architectural future viability”, an “increase in system maintainability” and through a changed management of core resources, which for many of the study participants meant its human resources. “Changed HR management” could arguably also be assigned to the value network dimension as it affects the collaboration across internal employees. Yet, we found that – at least for the cases in this study – the impact was strongest with regards to adaptations in the requirements as a core-resource. With reference to the value network dimension, we identified that the observed consequences include “new partnerships” and “improved customer interactions”.

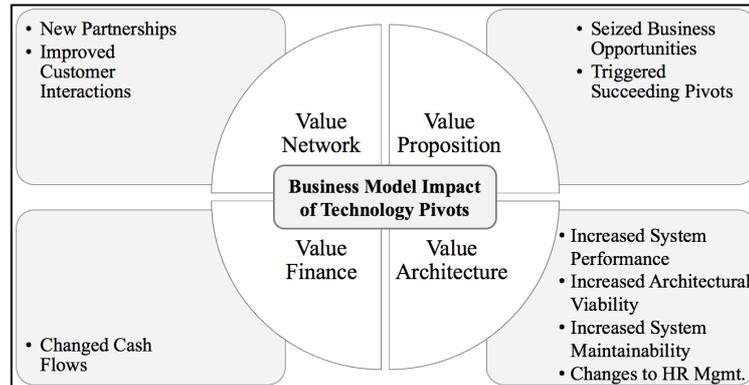


Figure 2. Preliminary Model of the Business Model Impact of Technology Pivots (applying the V^4 ontological structure of BMs by Al-Debei and Avison (2010))

As for the value finance dimension, we saw that cuts in business costs were most notable. Additionally, some study participants observed increases in expenses as new experts needed to be hired, licenses acquired or revenues shared. Thus, “changed cash flows” occurred. Generally, the most impacted values across the analysed case studies were the network and architecture dimensions, when a “necessary technology pivot” was performed, whereas performing an “opportunistic technology pivot” mostly impacted the value proposition dimension. To conclude, a good understanding of the impact of technology pivots on BMs supports informed-decision making by software startups and allows for theory development.

5 Conclusion

5.1 Implications for Theory

In contrast to studies analysing pivoting in software startups in a broader sense (Bajwa et al., 2017; Terho et al., 2015), our findings considerably extend the knowledge on one specific but very important type of pivot – technology pivots. Our study results in a preliminary theoretical model which considerably extends the knowledge about the role of technology pivots in software startups. It identifies a list of antecedents of technology pivots which empirically confirms the conceptualizations made by Ries (2011) and extends them by adding new antecedent categories. Additionally, it identifies a list of consequences resulting from technology pivots. Empirical evidence also indicates that three prerequisites need to be fulfilled before software startups perform technology pivots: (1) desirability, (2) feasibility, and (3) viability. Furthermore, we found empirical evidence that allows divisibility of technology pivots into two types. We identified ‘necessary’ technology pivots and ‘opportunistic’ technology pivots. The findings of this study indicate that exercising technology pivots is a subject of relevance for software startups in all four life-cycle stages (cf. Section 4.1, Section 4.3, and Table 2). Moreover, we illustrated that technology pivots describe rapid adaptations of core technology parts with a high level of BM impact. For this, we assigned the identified effects to the four dimensions of the V^4 ontological structure of BMs. Our results indicate that pursuing new business opportunities and thus, changing business strategies, is linked to performing technology pivots and adapting BM dimensions of the V^4 ontological structure of BMs (cf. Section 4.1). Through this, we highlighted that they are an important means of course correction for software startups during their search for a viable and scalable BM (Bajwa et al.,

2017). As we have seen, software startups introduce technological innovation to markets through technology pivots. Throughout our study, we identified cases where technology pivots not only introduced incremental improvements but fundamental innovation (e.g. ST0, ST1), which affected their key partner selection, value proposition, and customer segments. This finding challenges Ries' (2011, p. 172) statement that technology pivots are only "sustaining innovation, [leading to] an incremental improvement" that would not affect customer segments, value-capture model or channel partners. Instead, we see technology pivots as structured technological course corrections that allow the introduction of significant technical improvements for an existing offering as well as the introduction of IT-innovations to distinctly adapt and enhance the value created of products and services. Our findings contribute to the understanding of the relation between business strategy, BM development, BMI, and technology (Demil and Lecocq, 2010; Osterwalder et al., 2010). Moreover, our findings indicate that technology pivots have considerable impact on the internal business environment (cf. Section 4.4). Consequently, we believe that our findings support the development of comprehensive theories in the domain of BM development and BMI about the role of technology pivots in software startups.

5.2 Practical Implications

Our findings carry important implications for practice. First, software startups should consider when technology pivots become essential to reach strategic, financial or technical goals during all life-cycle stages, e.g., to reach alignment between their technological foundation, business strategy and BM. Failing to identify the need to pivot can substantially decrease the odds for startups on their way to becoming a viable and successful business. Here, it can help to differentiate as to whether a possible pivot is motivated through necessity or opportunity. Second, technology pivots can support software startups throughout BMI within markets in which technology is constantly changing (Ojala, 2016). Third, when considering technology pivots, software startups need to check if they fulfil the prerequisites. Fourth, software startups need to be aware of the consequences that can result from performing technology pivots and how this influences their BM. These considerations also need to include reflections about complications being created within the internal business environment through technology pivots.

5.3 Limitations & Avenues for Future Research

Our research has certain limitations. First, as a result of the chosen research approach using a multi case study design, the analysed cases might not represent a comprehensive list of all antecedents and consequences observable in regards to technology pivots. Second, due to the nature of a multi case study design, external validity is limited and needs to be confirmed in a quantitative study. Third, data triangulation via internal documents was not possible to the desired extent as decisions were often made based on the results of internal discussions. Future research can extend our findings in at least two promising directions. First, quantitative studies could be conducted to obtain a quantitative validation of our findings and to generalize the results. Second, research studies could quantify the business performance impact of technology pivots on software startups (Foss and Saebi, 2017).

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