Much more than “same solution using a different technology”: Antecedents and consequences of technology pivots in software startups

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Abstract. In search of a viable and scalable business model, software startups implement and deploy innovative software-based products and services. In the well-established Lean Startup Approach, pivoting – making major rather than minor adjustments – is a standard method applied in this process. Failing to pivot at the right time and for the right reasons can substantially jeopardize startup success. 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 one specific type of pivot – technology pivots – we use an embedded inductive multi-case research design to propose a model that identifies three prerequisites, five antecedent and nine consequence categories of technology pivots.

Keywords: Lean Startup, Technology Pivot, Antecedents, Consequences, Prerequisites, Business Model

1 Introduction

Software startups focus on the implementation and deployment of innovative software-based products and services in search of a viable and scalable business model (BM). In the well-established Lean Startup Approach, performing a pivot – an adjustment “[…] designed to test a new fundamental hypothesis about the product, strategy, and engine of growth” [1] – is the standard method applied in this search process. In this research, we focus on one specific type of pivot: *technology pivots* in software startups. In his seminal work, Ries [1] conceptualizes technology pivots as a means to “[…] achiev[ing] the same solution by using a completely different technology”. According to Ries, 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” [1]. Furthermore, according to Ries [1], technology pivots are

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supposedly sustaining innovation, that is, an incremental improvement that does not affect customer segments, value-capture model or channel partners.

The environments software startups operate in are dynamic, unpredictable, and even chaotic at times [2]. Throughout their search for a viable and scalable BM, they 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 [3, 4]. Given this highly changeable environment, we argue that the antecedents and consequences of technology pivots may go beyond what Ries [1] has conceptualized so far. The existence of further antecedents and consequences was already indicated in a study by Bajwa et al. [5] based on secondary data, in which the authors call for primary data studies to extend the existing knowledge base. Although technology is crucial for software startups, and their innovative products and services have a substantial impact on the global economy [6], surprisingly little effort has been made to theorize the role of technology in shaping entrepreneurial opportunities, actions, and outcomes [7]. To the best of our knowledge, no empirical study has yet elaborated on the antecedents and consequences of technology pivots. Hence, we posed the following research question: *What are the antecedents and consequences of technology pivots in software startups?*

In the absence of a sound theoretical basis that can be used to answer this question, we conduct an exploratory multiple-case study. 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 [8].

2 Background

2.1 Software Startups & Business Models

In order to understand the concept of pivots and their importance to the success of many startups, we need to first understand what characterizes startups. Startups frequently operate in highly volatile markets and try to "[…] solve a problem where the solution isn't well known" [9]. They often are new organizations with no operational history searching for a "[…] scalable, repeatable, [and] profitable business model" [10]. A software startup, in the context of this study, mainly focuses on the implementation and deployment of innovative software-based products and services [6].

A BM describes "[…] how a firm organizes itself to create and distribute value in a profitable manner" [11], by "[…] outlin[ing] the architecture of revenues, costs, and profits associated with the business enterprise delivering that value" [12]. In the case of software startups this means that a BM captures the value created through software-based products and services, to obtain a match between technological innovation (value creation) and BM (value capturing), identified throughout BM development. Without a well-defined BM, startups fail to capture the value of technological innovation. In dynamic market environments, in which technologies constantly change, BMs are not stable [13]. Software startups with a viable and scalable BM often need to iterate their existing BM because of evolving technologies, network positions or emerging competition [8, 12]. This process is called business model innovation (BMI). Using BMI, software startups react to "[…] major and unpredictable changes in the business environment" [14], which includes the "[…] discovery of a fundamentally different BM in an existing business" [15].

2.2 Lean Startup and Pivot

The Lean Startup approach encourages startups in environments of high uncertainty to develop their products and services iteratively [1, 10]. Its goal is to maximize the learning while keeping the resource investment efficient. To significantly change the development path based on learning, startups often exercise pivots [1, 5, 10]. Pivots are "[…] structured course corrections designed to test a new fundamental hypothesis about the product, business model, and engine of growth" [1]. Through fast iterations and "[…] by reducing the time between pivots, it is possible to increase the odds of success" [16]. However, Ries [1] also stated that the "[…] decision to pivot is so difficult that many companies fail to make it". Ries [1] initially presented ten different types of pivot that can appear in startups (e.g., product zoom-in, product zoom-out, technology). This list was confirmed and extended by Bajwa [17], who found three new pivot types. According to Ries' conceptualization [1], technology pivots help to "[…] achieve the same solution by using a completely different technology" in order to improve performance or reduce costs. This conceptualization, however, requires systematic and scientific validation. Yet, despite the acknowledged difficulty concerning the decision to pivot and the assumed importance of pivots in startup success, 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. [18] 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 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 development, BM development and BMI, so that an increase in successful startups can be achieved.

3 Method

The phenomenon of pivots is a relatively new field of research [17]. To understand the antecedents and consequences of technology pivots in software startups, an explorative research approach is chosen. This study applies a qualitative research design performed in the form of an embedded inductive multi-case study, according to Yin [19].

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, we selected software startups with B2C- and

B2B-BM from different focus industries. Our research sample contains 14 software startups (cf. Table 1) who completed one to three technology pivots. The authors could not identify any cases of discontinued technology pivots. We assigned pivot instances to life-cycle stages according to Kazanjian [20]. The cases were selected to achieve theoretical replication [19], with the aim of increasing the variance of antecedences and consequences of technology pivots across life-cycle stages [21].

Table 1. Overview of Case Study Participants

Name	*Type*	*Employees*	*Interviewee*	*Description of Technology Pivot(s)*	*Life-Cycle Stage*
ST0	B2C	450	CEO	(1) Replaced the core frontend framework of their SaaS product.	Commerc.
				(2) Shifted their focus to a mobile, instead of a desktop-based product.	Growth
ST1	B2C	270	VP Tech.	(1) Replaced their desktop-based product with a mobile-based product.	Growth
				(2) Replaced native mobile development with a cross-platform engine.	Stability
ST2	B2C	100	CEO	(1) Introduction of CRM system that includes core business logic.	Growth
				(2) Replacement of CRM system with self-made solution.	Growth
ST3	B2C	250	CTO	(1) Enhanced their core business logic with machine learning solution.	Stability
ST4	B2C	20	CEO	(1) Shifted their focus to a mobile, instead of a desktop-based product.	Growth
ST5	B2C	40	CTO	(1) Relocated extensive frontend logic into backend services.	Growth
				(2) Replaced the database and data storage logic of their SaaS product.	Growth
				(3) Replaced their mobile development framework.	Growth
ST6	B2B	15	CEO	(1) Replaced automation framework with a semi-manual approach.	Growth
ST7	B2B	50	CTO	(1) Replaced their client-server-architecture with a SaaS solution.	Concept. & Dev.
ST8	B2B	20	Dev. Lead	(1) Replaced their monolithic system architecture with micro-services.	Growth
ST9	B2B	10	CEO	(1) Replaced their architecture for data storage and data provisioning.	Commerc.
ST10	B2B	12	CTO	(1) Introduced a container-based architecture.	Commerc.
				(2) Replaced the core frontend framework of their SaaS product.	Commerc.
ST11	B2B	5	CTO	(1) Abandoned their mobile-based solution and created a BaaS solution.	Commerc.
ST12	B2B	15	CEO	(1) Replaced the core frontend framework of their SaaS product.	Concept. & Dev.
ST13	B2B	5	CEO	(1) Replaced their web-app solution with a mobile-based solution.	Commerc.

3.2 Data Collection

We relied on documents, recorded presentations and interviews as data sources. First, publicly available documents were collected. Then, to fully understand the nature of technology pivots, semi-structured interviews were conducted with senior managers who made the decision to perform a technology pivot. They were also able to observe at first hand the consequences that resulted from the technology pivot. In total, we conducted 14 interviews. 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 interviews had an average length of 39 min (median 40 min) and were transcribed. 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 analyzed.

4 Data Analysis

The data analysis was performed according to Yin [19], based on the transcripts of the semi-structured interviews. An iterative approach to the data analysis and theory building using open, axial, and selective coding was chosen [22]. The coding was done in Atlas.ti 8. 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 separate one hour workshops and became more robust and reliable [19]. During selective coding, the main categories were identified and linked to core-concepts. We used pattern matching as the analysis technique [19]. This final step of theory building resulted in a model.

5 Findings

Based on the identified antecedents and consequences of technology pivots, a preliminary theoretical model was created (cf. Figure 1). The model also shows the

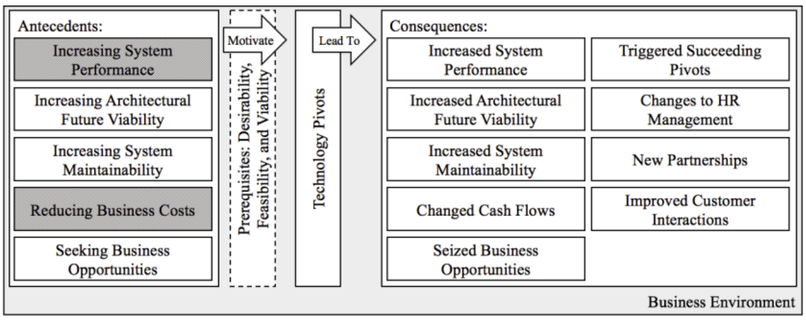

Figure 1. Preliminary Model of Antecedents and Consequences of Technology Pivots[1]

[1] A detailed version can be found online: https://goo.gl/G6VDYm

three identified prerequisites preceding the performance of technology pivots.

5.1 Antecedents of Technology Pivots

The identified antecedents of technology pivots were grouped into five distinctive categories. The first three categories (1-3) are related to the technology level, while the two remaining are focused on financial (4) or strategic aspects (5). The two antecedent categories shaded in grey were previously conceptualized by Ries [1]. It was found that technology pivots can be motivated by individual or multiple antecedents.

Increasing System Performance (1). For software products, system performance [23] is an essential quality attribute [24]. 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" (ST12) [2]). 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 not stable and responded slowly" (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, as stated by ST10, "[…] we knew that a certain set of features is only feasible with a significantly higher performance".

Increasing Architectural Future Viability (2). Some study participants were concerned about the future viability of their architectural design [23]. 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.

Increasing System Maintainability (3). Due to the nature of software startups, where decisions are made frequently and are fast-paced, implementation can be sub-optimal. As a result, system maintainability [23] can become a pressing issue. Some study participants reached a point where their systems became unmaintainable internally ("[…] considerable bottlenecks emerged. There were a few people that knew the implementation inside out, but when they were not available, development stopped" (ST8)). Furthermore, new staff needed considerable time to be inducted, and functionality was not verifiable, which led to unexpected system behaviors. In order to

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

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). At the same time, 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 exercised technology pivots by either implementing 3rd party solutions, which reduced internal development efforts or by developing enhanced home-made solutions, reviewing their product's technology needs.

Seeking Business Opportunities (5). As a result of the flexibility of their products and internal agility, pursuing new business opportunities is not uncommon for software startups [17]. Business opportunity recognition describes the "[…] alertness to changed conditions or to overlooked possibilities" [25]. ST5 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" (ST5). It was observed that strategy changes, caused by the available business opportunities, can go hand-in-hand with subsequently necessary technology pivots being performed (ST1, ST4, and ST10). These cases represent instances of pivots appearing in groups, as first identified by Terho et al. [26]. In other cases, as a result of their 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).

5.2 Prerequisites for Technology Pivots

Before the study participants exercised technology pivots, the following prerequisites needed to be fulfilled: (1) desirability, (2) feasibility, and (3) viability [27, 28]. As a first threshold, there need to be sufficient antecedents which confirm the desirability of a technology pivot. Subsequently, feasibility and viability are validated. Feasibility describes the skill and knowledge-based ability to implement technological changes. For this, the study participants utilized proof-of-concepts. Viability describes the possibility to successfully exercise a pivot based on the prevailing resources (e.g., HR, time, and money) and circumstances (e.g., roadmap). The participants estimated the required resources and made roadmap changes before performing technology pivots.

5.3 Consequences of Technology Pivots

The identified consequences of technology pivots were grouped into nine distinctive 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 BM [29] and were not assignable directly to any antecedent categories.

Increased System Performance (1). The study participants who aimed for an increase in system performance stated that performance goals were reached. 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 positive impact on the performance". Improved performance aspects mentioned included stability, response time, computing power, and availability, resulting in a considerably better user experience and reduced negative customer feedback.

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 and ST9). ST9 stated that "we always considered our long-term vision and what technology stack would be needed for it; more importantly, how we can get from our MVP to that long-term vision". Second, the new system architecture appeared to provide long-term future manageability (ST0 and ST3).

Increased System Maintainability (3). The study participants perceived that technology pivots had direct impact on the software development efficiency within their business ("[…] the whole implementation process is a lot faster now" (ST11). 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 implement functionality, which we could not implement before, which makes our customers happy" (ST8)).

Changed Cash Flows (4). In contrast to the obvious motivation to reduce costs (cf. Section 5.1), 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 development costs were reduced, in other cases, 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 ("[…] a financial investment to get the right package" (ST1)). While technology pivots generally led to increased revenues, ST0 and ST1 then had to pay certain shares of their revenues to key partners ("[…] we implemented a revenue-share-deal" (ST0)). Furthermore, revenues were no longer received from clients directly but from platform providers.

Seized Business Opportunities (5). Through technology pivots, study participants were enabled to validate further BM hypotheses ("New configurations of our business model became easier to validate" (ST4)). Furthermore, new business opportunities were enabled and utilized through technological 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 [26]. For example, new customer segments resulted in a subsequent *customer-segment pivot* (ST0, ST1, and ST11), at times surprising study participants ("It was a bit of a surprise that we reached them, because initially we aimed for another group of customers" ST7).

Changes to HR Management (7). Study participants reported a change in HR management in three aspects. 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)). Through the newly required skills, knowledge transitions for existing employees became necessary ("[…] a critical problem was that engineers did not know the new technology yet. Thus, they needed to invest time to learn it" (ST11)). Second, with regards to hiring opportunities, it was stated that "[…] it is a lot easier to find engineers now […] and especially engineers with the same mindset" (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 a result of less complexity and better manageability; as stated by ST10 "[…] we received the feedback from our employees that work is a lot more fun now", because "[…] you are less scared to break things, which increases satisfaction".

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". Furthermore, collaborations with the open source community were established by "[…] publishing a large part 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 to grow 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.

5.4 Business Environment Complications

Within the internal business environments in which technology pivots are exercised, we observed three complications. First, we found that exercising 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 exercised their first pivot. Second, exercising technology pivots creates considerable management overheads on the project at people management level as well as on a technical level. 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)).

6 Conclusion

6.1 Implications for Theory

Our study results in a preliminary theoretical model that considerably extends the knowledge on the role of technology pivots in software startups. It identifies a list of antecedents of technology pivots that empirically confirms the conceptualizations made by Ries [1] and extends them by adding new antecedent categories. Additionally, it identifies a list of consequences resulting from technology pivots. Empirical evidence also shown that three prerequisites need to be fulfilled before software startups perform technology pivots: (1) desirability, (2) feasibility, and (3) viability.

We have illustrated that technology pivots go beyond incremental changes and describe rapid adaptations of core technology parts with a high level of BM impact. They are an important means of course correction for software startups during their search for a viable and scalable BM [9]. Furthermore, our results show that pursuing new business opportunities and thus, changing business strategies, is linked to exercising technology pivots and adapting BM components (cf. Section 5.1). As we have shown, software startups introduce technological innovation to markets through technology pivots. Our findings contribute to the understanding of BMI in strategic entrepreneurship, which focusses on BMI as a means to exploring and exploiting opportunities within an external environment [30, 31]. Our findings enhance the understanding of the relation between business strategy, BM, and technology [29, 32]. Moreover, we have shown that technology pivots have considerable impact on the internal business environment (cf. Section 5.4). Our findings support the development of comprehensive theories in the domain of BM development and BMI about the role of technology pivots for future startups.

6.2 Practical Implications

Our findings carry important implications for practice. First, software startups need to identify at what life-cycle stage technology pivots become essential for them to reach strategic, financial or technical goals, 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 of startup success. Second, technology pivots can support software startups in exercising BMI within markets in which technology is constantly changing [13]. Third, software startups need to check if they fulfill the prerequisites when considering technology pivots. Fourth, software startups need to be aware of the consequences that can result from performing technology pivots. Finally, these considerations also need to include reflections about complications being created within the internal business environment in which technology pivots are performed.

6.3 Limitations & Avenues for Future Research

Our research has certain limitations. First, the cases included in this study all completed their exercised technology pivots. Thus, the antecedents and consequences might not represent a comprehensive list of all antecedents and consequences of technology 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, future research should quantify the business performance impact of technology pivots on software startups [8]. Second, future research could further increase the understanding of pivots as facilitating BM development and BMI.

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