

**Decision Making Under Radical Uncertainty: A Multiple Case Comparison of
Companies Creating New Technologies Featuring New Forms of Personal Data**

by

Andrew Lee Brooks

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Committee in charge:

Professor Coye Cheshire, Chair
Professor Steven Weber
Associate Professor Deirdre K. Mulligan
Professor Michael Nacht

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Abstract

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How do companies creating new technologies featuring new forms of personal data respond to the radical uncertainty of designing data ecosystems and accompanying business models with that sensitive data?

This dissertation answers this question with an empirical, inductive, multiple case comparison of the development of pioneering fitness technologies by Suunto, Garmin, and Adidas. Cases draw on interviews with key product team members who created these technologies and related public artifacts.

Teams responded to this uncertainty in different ways, leading to varying data ecosystem designs that created value in varying ways. Evidence strongly supports that teams' responses are primarily explained by their interpretation of the relative importance of user needs, followed by their interpretations of the relative importance of information economics concepts and their own expertise, and lastly regulations regarding the collection and use of personal data.

These findings pose implications for the creation of future technologies featuring new forms of personal data. Teams' responses will evolve as user needs evolve, and will offer insights into the dynamics and terms of teams' social license for their technologies. New regulations may impact how these ecosystem designs create value.

To Sara

Uncertainty is the essence of alpinism;
ignoring that destroys the experience.
– Steve House

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Chapter 1

Introduction

Today we see companies creating consumer fitness technologies that collect users' personal data, such as heart beats and steps, analyze that data to convert it into information, and return that information to users in situ. Companies creating these technologies include Fitbit, Nike, Apple, Garmin, Adidas, Strava, Suunto, and others. I call these technologies instrumented fitness experiences.

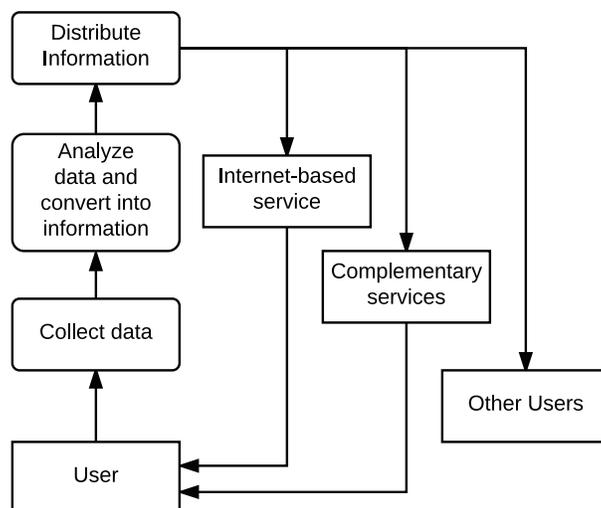
Instrumented fitness experiences collect various forms of personal data from users, ranging from the earlier physiological heart beats and steps to non-physiological location and speed. Data is collected via sensors, such as a three-axis accelerometer in a wristband, a chest-worn heart rate monitor, or a mobile phone's global positioning sensor. Algorithms convert that collected data into familiar and new forms of information, such as running speed and training effect, respectively. Each distributes that information to users via an Internet-based service, such as a web site or mobile phone application, where users may also share their collected data and information with other users. Some allow users to share their data and information with other companies offering complementary services.

Borrowing a concept from the natural sciences, underlying an instrumented fitness experience is a data ecosystem. A data ecosystem is an arrangement of interactions and processes that collect and distribute users' data and information. As depicted in Figure ?? Instrumented Fitness Experience Data Ecosystem on page ??, a key characteristic of this data ecosystem is a user-focused feedback loop, where users' data is collected, analyzed, and returned as information to the user.

Instrumented fitness experiences' data ecosystems designs differ: the type of data collected and how it is collected, and what data and information is distributed, to whom, and how.¹ Fitbit's One collects users' steps via an accelerometer inside a pocketable device, while Apple's Watch Series 2 collects users' steps and heart rate via an accelerometer and optical heart rate sensor, respectively, inside a wrist-worn watch. Strava foregoes collecting data with its own sensors, instead relying on other companies' devices. Fitbit One users can

¹These data ecosystem designs were gathered from reviewing the respective instrumented fitness experiences' public product documentation to assess what personal data they collected from users and how, and how and what data and information they distributed and returned to users and others.

Figure 1.1: Instrumented Fitness Experience Data Ecosystem



share their collected data with myriad complementary services provided by other companies, while Garmin Fenix 5 users may install other companies' complementary applications on their Fenix 5 watch. The designs of data ecosystems underlying instrumented fitness experiences vary.

Instrumented fitness experiences are created within technology companies by product teams, groups of individuals who conceptualize, develop, and release products to the consumer market. (Eppinger and Ulrich 2015) Individuals on these teams serve various roles and contribute their knowledge and skills to the product development process. Product managers identify business opportunities in the marketplace, and specify new product and service concepts to capitalize on those opportunities. Designers and engineers convert those concepts into products and services that are then released to consumers.

Product teams are tasked with releasing products and services that create value, ideally for both users and the company. That value can take multiple forms, from serving user needs to providing revenue to the company through sales of the product or service to consumers. For product teams developing instrumented fitness experiences, value is created through the design of the data ecosystem: determining what and how data is collected, and what and how data and information is distributed, to whom, and for what purpose. A product team's configuration of these elements is the design of the data ecosystem for their instrumented fitness experience.

Product teams developing instrumented fitness experiences are operating in a world of radical uncertainty regarding how to design their data ecosystems. Also known as Knightian uncertainty, radical uncertainty is a form of immeasurable uncertainty, where the future is unknown and cannot be known. (Knight 2012) Product teams' uncertainty stems from multiple, related uncertainties.

Product teams are uncertain regarding the new forms of personal data that can be col-

lected from users. Physiological data, such as heart and respiratory rate, are unlike other forms of personal data because it is more detailed and nuanced, and can be collected longitudinally over days, months, and years. Physiological data bears similarities to Big Data, which is characterized by its volume, variety, velocity, and veracity. Personal data such as name, birth date, Social Security number, and education level, are less dynamic. Such personal data is generated at a lesser rate and changes less frequently than physiological data.

Product teams are further uncertain regarding how to reliably collect physiological data, reliably analyze it, and return it to users as useful information. Physiological data may be collected via an array of sensors in various forms, from three-axis accelerometers in pocketable devices and galvanic skin response sensors in clothing to wrist-worn optical sensors. Each of these methods offers affordances and poses challenges that are still being understood. (Pantelopoulos and Bourbakis 2008) Analyzing the physiological data heart rate variability may be done myriad ways with no agreed-upon method, resulting in differing values that may impede its adoption. (Berntson et al. 1997) The interpretation of physiological data, such as beats per minute with heart rate, is shown to vary considerably amongst individuals. (Slovák, Janssen, and Fitzpatrick 2012; Tholander and Nylander 2015) The usefulness and efficacy of providing physiologically-based information to users, such as their daily steps to improve their fitness, is mixed. (Harris et al. 2015; Jakicic et al. 2016) Such uncertainty is seemingly rarer for non-physiological personal data.

Product teams are uncertain regarding individuals' acceptance of physiological data collection, with evidence suggesting individuals are concerned regarding the collection of their non-physiological personal data. (Madden and Rainie 2015; Rainie and Anderson 2014; Rainie and Duggan 2016) It is unclear if and how individuals' acceptance of physiological and non-physiological personal data are similar or different, and why. Product teams are uncertain regarding the forces shaping what and how physiological data is collected and distributed within an instrumented fitness experience data ecosystem.

In spite of such uncertainty, product teams are developing and releasing instrumented fitness experiences. As noted earlier, different product teams design the data ecosystems for their instrumented fitness experiences in different ways. Those varying designs feature different ways to create value.

For example, some data ecosystem designs feature the collection of users' physiological data with the company's own technology, while others utilize another company's technology. In the former, value is allocated to the company providing the instrumented fitness experience. For the latter value in the data ecosystem is allocated to the other company.

As another example, some data ecosystem designs feature users' ability to share their collected data with an outside company's complementary service. In such a case, value in the data ecosystem is created and allocated to the outside company providing the complementary service, the user benefitting from the complementary service, and to the instrumented fitness experience provider who enabled the relationship between the user and outside company. Other ecosystem designs do not feature such distribution of users' data, and thus do not create such value in their ecosystem.

Different product teams have very different theories regarding where value will be created in their data ecosystems and the strategies for creating that value. My task in this dissertation is to explain where those differences come from, and what consequences they have for the design of data ecosystems for future instrumented fitness experiences. Along the way I will explore the more general questions of how product teams respond to radical uncertainty in the marketplace. Understanding product teams' response to such uncertainty is critical because it is unclear what explains how product teams design the data ecosystems for their instrumented fitness experiences. Our lack of knowing how product teams design these data ecosystems is a problem because product teams may pursue strategies that do not create value for themselves and users.

In such cases companies and product teams expend resources that could be dedicated to other opportunities. Users are unable to realize the potential benefits of adopting instrumented fitness experiences, which may improve users' fitness, health, and general well-being. Product teams may pursue strategies that cause or contribute to users' harm, creating negative value for users.

Not knowing is a problem because this phenomena, product teams' uncertainty regarding how to design these data ecosystems, will repeatedly present itself. New forms and types of physiological and personal data will become available, as well as news means to collect, analyze, and distribute that data.

A number of factors could explain how product teams design the data ecosystems for their instrumented fitness experiences. Referring to Figure ?? Instrumented Fitness Experience Data Ecosystem on page ??, the process of collecting and distributing users' data is key to creating value with the data ecosystem design. For example, a product team's decisions regarding what and how data is collected for users impacts the design. Decisions regarding what and how collected data is distributed and to whom, including to users and other companies, impact the data ecosystem design as well. Product teams' design decisions may be informed by concepts from several fields, including information economics, law and policy, management science, and user-centered design and innovation. The reasoning for how and why these fields and related concepts are applicable to understanding product teams' decisions is detailed later in Chapter 2: Guiding Concepts and Chapter 3: Empirical Study Design. An overview of these fields and concepts follows.

Information economists may envision instrumented fitness experiences as multisided platforms connecting different types of users with one another. Multisided platforms create value through enabling interactions between multiple types of users. (Armstrong 2006; Hagiu and Wright 2015; Rochet and Tirole 2003) For instrumented fitness experiences, users include those whose data is collected and analyzed and companies offering complementary services to those users. Information economists might argue that product teams would design their data ecosystems by enabling interactions within and amongst those user groups, as doing so would spur positive network effects. (Eisenmann, Parker, and Alstyne 2006; Gawer 2011; Parker and Alstyne 2008; Parker and Van Alstyne 2010; Shapiro and Varian 1999) Positive network effects occur when increased usage of a platform by users increases the value of the platform for users and the platform provider. For information economists, product

teams would design the data ecosystems for the instrumented fitness experiences by enabling interactions amongst users that then generate positive network effects.

Researchers in the law and policy community may argue that regulations and social license terms related to users' personal data explain how product teams design the data ecosystems for their instrumented fitness experiences. For example, the European Union's Data Protection Directive 95/46/EC regulates the collection and use of personal data by companies offering services to citizens of European Union-member countries.² Similar personal data-oriented regulations exist in other regions of the world, including the United States' Children's Online Privacy Protection Act³ and California Online Privacy Protection Act of 2003.⁴ Researchers have found that in the absence of and alongside regulations, companies may secure a social license to operate from a community of stakeholders potentially affected by the companies' actions. (Bamberger and Mulligan 2015; Gunningham, Kagan, and Thornton 2003; Gunningham, Kagan, and Thornton 2004) Companies secure that social license through complying with specific terms outlined by those stakeholders. For instrumented fitness experiences those terms may relate to the collection and use of personal data. Law and policy researchers might argue that product teams would design their data ecosystems by complying with relevant regulations, as well as by identifying and fulfilling required social license terms.

User-centered design and innovation researchers may argue that product teams design their data ecosystems through fulfilling users' needs. Research in this community has shown that interacting with users to identify their needs, particularly lead users, then designing and releasing products that fulfill those needs creates value for users and the companies providing those products. (Magnusson 2009; Schweisfurth 2012; Schweisfurth and Raasch 2015; von Hippel 1986; von Hippel 2005) Instrumented fitness experience users may desire the ability to collect their data from multiple sensors, such as a chest-worn heart rate monitor and shoe-worn cadence sensor. The product team would design the ecosystem to collect data from multiple sensors, creating value for those users' whose need is now fulfilled. For the user-centered design and innovation research community, a product team's decisions regarding designing their data ecosystem would reflect their decisions to fulfill user needs.

The management science community may argue that product teams' data ecosystem designs reflect their knowledge and expertise regarding aspects of the design. Researchers have found that technology companies look outside their own organization for knowledge, particularly when they deem they are not expert. (Balka, Raasch, and Herstatt 2014; Chesbrough 2006; Chesbrough 2013; Leonard-Barton 1995) In such cases companies integrate outsiders' knowledge, such as their technologies and intellectual property, into their own operations. For instrumented fitness experiences, a product team may deem it is not knowledgeable regarding technical aspects of collecting users' data and choose to design the data ecosystem by

²European Union, Directive 95/46/EC of the European Parliament and of the Council on the Protection of Individuals with Regard to the Processing of Personal Data and on the Free Movement of Such Data, 24 October 1995.

³Children's Online Privacy Protection Act. 16 C.F.R. Section 312.

⁴The Online Privacy Protection Act of 2003, Cal. Bus. & Prof. Code Section 22575-22579

licensing another company's data collection technology. Researchers may argue that product teams would design their data ecosystems through tapping others' knowledge regarding collecting and distributing users' data.

The epistemological status of these four fields varies, from the emerging exploration of the legal and policy aspects of personal data-oriented technologies to the more established information economics, management science, and user-centered design and innovation fields. Each emphasizes a particular driving force that might explain product teams' decisions regarding their data ecosystem designs. Each force may be present to some degree. My starting proposition is that I can disentangle the forces' impact on product teams' data ecosystem design decisions, and in so doing uncover which forces are operating most strongly. In order to do so, I pose the following research questions:

- What were product teams' key decision points when designing the data ecosystems for their instrumented fitness experiences?
- What factors influenced product teams' decisions?
- How did those decisions impact the creation of value in their respective data ecosystems?

The dissertation addresses these research questions with the structured focused comparison case study method. This method was chosen because it offers a disciplined means to rigorously analyze complex real world phenomena. A collection of standardized questions are posed to detailed, narrative descriptions of one or many multiple real world phenomena in order to identify the explanatory factors for each phenomena. (George and Bennett 2005) Those explanatory factors contribute to cumulative knowledge and theory regarding the phenomena, which can then be applied to understand similar phenomena.

The phenomena of inquiry for this dissertation are pioneering product teams' decisions designing the personal data ecosystems for their instrumented fitness experiences. Per the structured focused comparison method, these phenomena are represented as cases. Cases for this dissertation were selected to secure a range of regulatory and social landscapes, including the United States and Europe, because such diversity may feature a broader range of data ecosystem designs and possible explanatory factors. All cases feature an instrumented fitness experience released during their initial public emergence from 2004-2010, when as noted earlier product teams were most uncertain regarding their data ecosystem designs. Further aspects of the method are detailed in Chapter 3: Empirical Study Design.

The dissertation features three cases: the Suunto T6 of 2004, Garmin Forerunner 50 of 2007, and Adidas miCoach Pacer of 2010. Each case draws on a pair of data sets: interviews with key decision makers on the product teams, and a suite of public artifacts related to the instrumented fitness experiences, such as user manuals, privacy policies, and marketing literature. Each case details and analyzes the data ecosystem design decisions faced by the product teams throughout the product development process, from initial concept to public release, and features a figure depicting the data ecosystem. The cases were iteratively

analyzed with a suite of questions to inductively identify the explanatory factors impacting product teams' decisions regarding the design of the data ecosystems. The questions draw from concepts in the four fields cited earlier and are detailed in Chapter 3: Empirical Study Design.

The dissertation argues that the key determinant of product teams' response to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences is their interpretation of the relative importance of user needs. Product teams' interpretation of the relative importance of information economics concepts and their own expertise are minor determinants of their responses. Product teams' interpretation of the relative importance of regulations are not determinant of their responses. Each of these arguments are substantiated in Chapter 8: Explaining the Variance.

These findings contribute to our understanding of how the burgeoning economy of personal data might develop, and pose implications for future instrumented fitness experiences' data ecosystem designs. These contributions and implications are detailed in Chapter: Conclusion, and of note include the following. Teams' responses to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences will evolve as user needs evolve. Teams' responses to emerging regulations may reset the figurative playing field regarding how value is created in these ecosystems. Teams' responses offer insights into their social license for their instrumented fitness experience.

This dissertation consists of three parts. Part One continues with Chapter 2: Guiding Concepts, a review of related concepts from the information economics, law and policy, user-centered design, and management science domains, and Chapter 3: Empirical Study Design. Part Two includes the three individual cases as Chapters 4, 5, and 6. Part Three's Chapters 7, 8, and 9 feature the case analysis, key findings, and the implications for future instrumented fitness experiences' data ecosystem designs. The Appendix includes the Interview Guide and Codebook Excerpts.

Chapter 2

Guiding Concepts

2.1 Introduction

This dissertation examines the impact of four driving forces on pioneering product teams' responses to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences. Each force draws on a body of theory from which I deduced a hypothesis explaining product teams' responses, which take the form of data ecosystem design decisions. The four hypotheses are referred to as Information Economics, Regulations, User Needs, and Team Expertise. My decision to draw on these bodies of theory to form these hypotheses is detailed in Chapter 3: Empirical Study Design.

The goals of this chapter are twofold: to explain each hypothesis and its related body of theory and to provide the reader with the knowledge needed to assess each hypothesis against the evidence presented and analyzed in the cases.

2.2 Information Economics

The Information Economics hypothesis proposes that the key determinant of product teams' responses to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences is their interpretation of the relative importance of key concepts from information economics theory. These concepts include multisided platforms, network effects, penetration pricing, and differentiation. Together these concepts constitute a hypothesis explaining product team's data ecosystem design decisions.

Multisided platforms are information-mediated services that enable interactions between different types of users (Armstrong 2006; Evans 2003; Gawer 2009; Hagiu and Wright 2015; Rochet and Tirole 2003) Enabling those interactions creates value for users and the platform provider. Multisided platforms are further characterized by the presence of network effects, a phenomena where the increased usage of a platform by one user impacts the creation of value for other users. (Eisenmann, Parker, and Alstyne 2006; Gawer 2011; Parker and Alstyne 2008; Parker and Van Alstyne 2010; Shapiro and Varian 1999)

Companies creating multisided platforms create value for themselves through exercising rents, such as fees, from one or multiple user groups. (Baldwin and Woodard 2008) Contemporary multisided platform providers include Facebook, Google, Airbnb, eBay, StubHub, Ticketmaster, and PayPal. (Hagiu 2014) For example, eBay charges fees to sellers to auction their items on the site. StubHub charges fees to both buyers and sellers on the ticket exchange site.

The social networking site Facebook is an illustrative example of a multisided platform, as it enables interactions between multiple user groups. (Evans and Schmalensee 2016) Individual users share personal messages with other individual users interested in receiving those messages. These individual users value the ability to exchange personal messages with one another. The more members of an individual user's community who are also Facebook users, the greater the value created for that individual user.

Facebook also enables interactions between advertisers and individual users. Advertisers value the ability to display their messages to those individual users. The greater the number of individual Facebook users, the greater the value created for those advertisers. Facebook charges advertisers fees to display their messages to users. Facebook also enables interactions between software application developers and individual users. Software applications developers value the ability to create applications, such as games, for individual users. The greater the number of individual users, the greater the value created for those application developers. Users value the ability to use these applications on Facebook.

As noted earlier, network effects are a key form of value creation for multisided platforms. Companies design their multisided platforms to spur multiple types of network effects, including same-side and cross-side network effects. (Eisenmann, Parker, and Alstyne 2006) Same-side network effects occur when an increase in the number of one type of users impacts the value of the platform for the same type of users. (Eisenmann, Parker, and Alstyne 2006) Same-side network effects may be positive, where increased usage by one type of users makes the platform more valuable for the same type of users. Same-side network effects may also be negative, where increased usage by one type of users makes the platform less valuable for users.

Researchers have found that companies pursue a variety of strategies to spur positive same-side network effects. These strategies must be observed in the cases for the Information Economics hypothesis to be supported as the lead determinant of the data ecosystem design. The first strategy focuses on pricing, where the company offers access to the platform at a price lower than both the cost of providing the platform to users and the perceived value it returns to those users. (Eisenmann, Parker, and Alstyne 2006) The strategy reduces price as a barrier to user adoption. Also referred to as penetration pricing, the goal with this strategy is to attract and establish an installed base of one type of users. (Shapiro and Varian 1999) The strategy is apt when launching a new platform in a new domain because those early users may then be less prone to switch to a subsequently released competing platform. Such a switch to another platform poses costs for users, which are detailed later in this section.

A second strategy for spurring positive same-side network effects focuses on product differentiation, providing users with features and functionality not found with competing

platforms. (Shapiro and Varian 1999) Users desiring that functionality are then drawn to the platform. Providing such functionality figuratively raises users' switching costs, the amount of effort users incur and features lost when adopting a competing platform. (Shapiro and Varian 1999) When that functionality is exclusive to the platform, such as protected by a patent, users' switching costs can be so high that they are effectively locked into the platform. Pursuing such a lock-in strategy can generate and maintain same-side network effects. (Shapiro and Varian 1999)

Cross-side network effects occur when an increase in the number of one type of users impacts the value of the platform for a different type of users. (Rochet and Tirole 2003; Eisenmann, Parker, and Alstyne 2006) As with same-side network effects, cross-side network effects can be either positive or negative. Increased usage by one type of users may make the platform more or less valuable for a different type of user. Platform providers spur cross-side network effects by figuratively opening the platform to another type of users.

Returning to Facebook as an example, when launched in 2004 the platform featured two types of users: individual users who shared personal messages and individual users who received those messages. (Evans and Schmalensee 2016) Facebook opened the platform to advertisers in 2004 and software application developers in 2007. Opening the platform to additional types of users created value by enabling new forms of interactions amongst different types of users. Facebook monetizes these interactions through charging advertisers fees to interact with individual users.

Facebook's history illustrates the challenges platform providers face determining when and how to foster cross-side network effects. That is, identifying when to allow a different types of users to access a platform, and the quantity of users needed to spur positive network effects. (Eisenmann, Parker, and Van Alstyne 2008) Facebook faced a dilemma when considering opening the platform to advertisers and later software application developers to spur cross-side network effects.

Opening the platform to advertisers could spur cross-side network effects, which Facebook could monetize through charging advertisers fees. However that cross-side network effect could be tempered if too many advertisers joined the platform, as they would compete with one another to interact with individual users. Such competition would lead to negative same-side network effects for advertisers. Advertisements could spur negative cross-side network effects for users, as users may react negatively to these advertisements. Opening the platform to software application developers posed similar impacts on same-side and cross-side network effects.

Researchers propose various strategies to help companies determine if, how, and when to open a platform to another type of users to spur cross-side network effects. Any of the following cross-side network strategies must be observed in the cases for the Information Economics hypothesis to be supported as the lead determinant of teams' responses. On the abstract end of the strategy spectrum, these decisions are related to openness and control. (Shapiro and Varian 1999) In order to maximize the value of a new technology, a company will need to share that value with others. But controlling the technology will be valuable to the company if it proves popular. Relinquishing control over the technology and opening it

to other types of users is a cautious strategy, one that they propose increases the total value added in a domain.

Alternatively, companies may pursue a two-stage process regarding opening a platform to more types of users. (Eisenmann and Hagiu 2007) First, the company focuses exclusively on providing services to the type of users on one side of the platform. Then once that first side is established, in the second stage the company opens the platform to a second type of users. That second type of users is attracted by the opportunity to interact with to the established first type of users.

The Palm group of mobile technology devices pursued this two-stage strategy in the early 2000s. (Eisenmann and Hagiu 2007) The company initially developed its devices, operating system, and software itself, and only after selling millions of devices it opened the platform to other software developers. Amazon also pursued this two-stage strategy, where only after establishing itself as an online retailer did it welcome other sellers to interact with buyers via its Marketplace feature. (Rysman 2009) In both examples the companies established one side of users, then expanded to a second side of different user types.

A third strategy regarding opening a platform to additional types of users focuses on business strategy complexity. (Evans and Schmalensee 2016) Each type of user and corresponding side added to a platform increases the complexity of the business model, as the company needs to manage relationships with those users and monitor their impact on cross-side and same-side network effects. Focusing the platform on a limited number of user types from the outset reduces this complexity, and allows the company to add user types and sides as their market matures. The company can then observe and react to the impact of these additional user types on same-side and cross-side network effects.

In summary, the Information Economics hypothesis proposes that the key determinant of product teams' responses to their uncertainty is their interpretation of the relative importance of key concepts from information economics theory: multisided platforms, network effects, penetration pricing, and differentiation. Assessing evidence for this hypothesis will reveal the role these concepts played in shaping product teams' data ecosystem design decisions. For this hypothesis to be strongly supported, all of the following evidence must be observed in the cases. The observation of some, but not all of this evidence, will be interpreted as minor support for the hypothesis.

First, the product team envisions the instrumented fitness experience as a multisided platform enabling interactions between users sharing their collected fitness activities and other users interested in viewing those activities. That vision could manifest in the ecosystem featuring both user types and their ability to interact with one another. Enabling these interactions will create value for users.

The product team pursues a penetration pricing strategy, pricing the instrumented fitness experience below cost, less than competitors' comparable offerings, or lower than users' perceived value with the goal of spurring user adoption and same-side network effects. The product team's decision to minimize the price may manifest in the data ecosystem foregoing costly features and functionality.

The product team chooses to differentiate their instrumented fitness experience relative

to competing technologies, with the goal of spurring user adoption and same-side network effects. That decision may manifest in the data ecosystem as an exclusive feature or functionality not found in competing data ecosystems. For example, the data ecosystem may collect a unique type of data from users or return a new form of fitness-related information to users.

Lastly, the product team increases the number of types of users featured in the data ecosystem, with the goal of driving cross-side network effects. The data ecosystem expands beyond users sharing their fitness activities and users viewing those activities to include one or more new types of users. These new types of users may include advertisers, similar to Facebook, or companies offering complementary services to users. Readers may observe product teams debating if and when to add new user types: from the outset when creating the instrumented fitness experience, in a two-stage process, or as events in the marketplace unfold.

In conclusion, the Information Economics hypothesis serves as one of four candidate explanation for product teams' responses to their uncertainty regarding designing the data ecosystem for their instrumented fitness experiences. In the face of such uncertainty, product teams design the data ecosystems based primarily on their interpretation of the relative importance of the information economics concepts of multisided platforms, network effects, penetration pricing, and differentiation.

2.3 Regulations

The Regulations hypothesis proposes that the key determinant of product teams' response to their uncertainty is their interpretation of the relative importance of regulations regarding the collection and use of personal data. Such regulations exist throughout the world, including for the cases in this dissertation the United States of America, European Union (EU), and EU-member countries Germany and Finland. This section details these regulations, tracing their emergence and evolution to the time product teams featured in this dissertation designed the data ecosystems for their instrumented fitness experiences. Through learning these regulations readers will be equipped to analyze how product teams' interpretation of the relative importance of these regulations impacted their response to their uncertainty.

Regulations regarding the collection and use of personal data by organizations emerged in Europe in the early 1970s. (Bignami 2011) At the time as today, new technologies presented new ways to collect and use personal data. Out of concern for how these technologies may be used, in 1977 Germany introduced the first national regulations regarding personal data protection. (Riccardi 1983) The Federal Data Protection Act (BDSG) defined personal data as "details on the personal or material circumstances of an identified or identifiable physical person" and assigned individuals rights regarding their data.¹ Individuals had the right to

¹The German Federal Data Protection Act of 1977. Gesetz zum Missbrauch personenbezogener Daten bei der Datenverarbeitung [Act Concerning the Abuse of Data in Data Processing], Jan. 27, 1977, BGBL I at 201.

know what data was collected about them, access their data, correct inaccurate data, and delete the data if collected without permission. While first of its kind, researchers criticized the Federal Data Protection Act for its imprecise language and failure to award damages to individuals wronged by the misuse of their personal data. (Riccardi 1983) The Federal Protection Act is revisited later in this section.

In 1980 the international Organization for Economics Cooperation and Development (OECD) and its thirty-five member countries issued guidelines, the Recommendations of the Council Concerning Guidelines Governing the Protection of Privacy and Transborder Flows of Personal Data.² The non-binding Recommendations detailed protections for individuals against harm as a result of organizations collecting and processing their personal data. The Recommendations define personal data as “any data or information relating to an identified or identifiable individual.” Building on the German Federal Data Protection Act, individuals are assigned rights, including the right to know that their personal data is collected, why, and by whom. Individuals additionally have the right to know what data is collected, correct that data if inaccurate, and access that data in a usable form. The Recommendations prohibit the collection of certain sensitive personal data without additional legal safeguards. Organizations may not use collected data in ways not disclosed to users, must keep data secure, and must comply with the terms of the agreement when transferring data to other regions. Individuals may hold organizations accountable for not adhering to the protections. Since the Recommendations were non-binding, member countries were left to implement them as they deemed appropriate. While an OECD member, the United States did not implement the Recommendations.

In 1981 the Council of Europe implemented the first legally binding international personal data protections with the Convention for the Protection of Individuals with Regard to Automatic Processing of Personal Data.³ The Convention is largely based on the earlier-described OECD Recommendations. Organizations providing personal data oriented services must fulfill similar obligations as the Recommendations, and individuals are assigned similar rights.

Throughout the 1980s countries in Europe adopted varying regulations regarding personal data. In an effort to standardize those regulations, in 1995 the European Union adopted Data Protection Directive 95/46/EC.⁴ The Directive details individuals’ rights and organizations’ obligations regarding the collection and use of personal data in European Union Member countries. Those rights and obligations are similar to those specified by the Federal Data Protection Act, Recommendations, and Convention, and introduce new requirements. Individuals’ rights include knowing that their personal data is collected, what data is col-

²Organization for Economic Co-operation and Development. Guidelines on the Protection of Privacy and Transborder Flows of Personal Data. <https://www.oecd.org/sti/ieconomy/oecdguidelinesontheProtectionofPrivacyandTransborderFlowsOfPersonalData.htm>

³Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data. ETS No.108. January 28, 1981. <https://www.coe.int/en/web/conventions/full-list/-/conventions/treaty/108>

⁴Directive 95/46/EC of the European Parliament and of the Council of October 24 1995 on the Protection of Individuals with Regard to the Processing of Personal Data and on the Free Movement of Such Data.

lected, why, and by whom, the ability to ensure the accuracy of and access to their data, and the right to hold organizations accountable for not following the Directive. Organizations are obligated to only use data in ways disclosed to users, secure the data, and ensure that they comply with the Directive regardless of where the data is transferred. Once approved, European Union member countries were obligated to implement their own binding laws.

Of relevance to this dissertation's cases, Germany and Finland implemented their Directive-required regulations by updating existing and creating new regulations, respectively. Germany updated the Federal Data Protection Act⁵ to comply with the Directive, while Finland introduced its Personal Data Act (523/1999).⁶ Both regulations extend specific aspects of the Directive. Germany's regulations require that organizations collect the minimum data required for their personal data services, while Finland's regulations make no such stipulation. Both permit the collection of health-related data from individuals, as long as that collection complies with the collection of other forms of personal data. Both specify that organizations may distribute collected data to other organizations with users' prior consent. German regulations state that individuals must be able to access their collected data free of charge, and the organizations collecting data must utilize the services of a data protection officer to ensure regulatory compliance.

Personal data regulations in the United States evolved differently than in the European Union. In contrast to the European Union's encompassing Directive and country-specific regulations, the United States' regulatory landscape is composed of a collection of regulations governing various types of personal data by varying types of organizations. (Bamberger and Mulligan 2015) Unlike the European Union regulations, the United States' regulations feature varying definitions of personal data, while also assigning varying rights to individuals and obligations to organizations collecting and using that data. These regulations are detailed below.

The Fair Credit Reporting Act of 1970 (FCRA) focuses on protecting individuals' right to access consumer data about themselves.⁷ Such data includes a consumer's outstanding debts, debt payment history, available credit, and credit utilization. The Act requires that companies collecting this data, such as banks, make it available to users in the form of a credit report, and that users have the right to challenge incorrect data. The Act stipulates that those collecting the data may make it available to other organizations, such as potential employers, but only with consumers' approval. The Fair Credit Reporting Act is noted for its narrow definition of personal data.

The Privacy Act of 1974 regulates the collection and use of a range of personal data by federal agencies.⁸ Personal data includes an individual's education, financial transactions, and criminal, medical, and employment history. That data may take the form of text, numbers, fingerprints, voiceprints, or photographs. The Act applies to all federal agencies,

⁵The German Federal Data Protection Act. http://www.gesetze-im-internet.de/englisch_bdsgr/

⁶The Finland Personal Data Act 523.1999. <http://www.finlex.fi/en/laki/kaannokset/1999/19990523>

⁷The Fair Credit Reporting Act 15 U.S.C. Section 1681

⁸The Privacy Act of 1974. Pub.L. 93?579, 88 Stat. 1896, enacted December 31, 1974, 5 U.S.C. Section 552a.

but does not apply to courts, the Executive branch, or organizations that are not defined as agencies. Only United States citizens are protected by the Act. The act established four principles. Individuals may be able to see any collected on them by a federal agency. Agencies must be follow a Code of Fair Information Practices when collecting and using individuals' personal data, including ensuring the accuracy, completeness, timeliness, and relevance of the data. Agencies may not share individuals' data with other individuals or other agencies without consent, except in the case of certain narrow exemptions, such as by Congress, the Census Bureau, or to fulfill a Freedom of Information Act request. Individuals may sue the government for failure to follow the Act. The Privacy Act is notable because it features a broader definition of personal data than the earlier Fair Credit Reporting Act, and does not apply to non-government organizations like the Fair Credit Reporting Act.

In 1996 the United States adopted the Health Insurance Portability and Accountability Act (HIPAA), which focuses on the collection, transmission, and storage of individuals' health data by covered entities.⁹ Per HIPAA, health data is "any information about health status, provision of health care, or payment for health care that is created or provided by a covered entity" and can be linked to a specific individual. A subset of this data is labeled "protected health information," including but not limited to Social Security numbers, biometric identifiers such as fingerprints and retinal scans, facial photographs, Internet protocol addresses, web site addresses, and device identifiers. Four types of entities must comply with HIPAA.¹⁰ Health plans, including health insurance companies, health maintenance organizations, employer-sponsored health plans, and government health-related programs. Clearinghouses, which are organizations that process health information. Providers, including doctors, clinics, psychologists, pharmacies, chiropractors, nursing homes, and dentists. Lastly, business associates that help deliver health care services, such as consultants.

HIPAA's Privacy Rule specifies individuals' rights and entities' obligations regarding protected health information.¹¹ Individuals have the right to know when their protected health information is collected, disclosed, as well as request that entities not share their protected health information. Individuals have the right to access their collected protected health information, and amend that information if inaccurate. Entities are obligated to comply with all HIPAA requirements, including but not limited to making available a privacy policy detailing how it complies with HIPAA and assigning a representative to ensure HIPAA compliance. HIPAA is notable in the evolution of regulations in the United States because it features aspects of European Union regulations detailer earlier, including the designation of a representative to ensure data protections.

In 1998 the Unites States adopted the Children's Online Privacy Protection Act (COPPA)

⁹Health Insurance Portability and Accountability Act of 1996. 45 CFR Part 160 and Subparts A and E of Part 164 <https://www.hhs.gov/hipaa/for-professionals/privacy/laws-regulations/combined-regulation-text/index.html>

¹⁰United States Department of Health and Human Services. National Institutes of Health. To Whom Does the Privacy Rule Apply and Whom Will It Affect? https://privacyruleandresearch.nih.gov/pr_06.asp

¹¹United States Department of Health and Human Services. Health Information Privacy. Summary of the HIPAA Privacy Rule. <https://www.hhs.gov/hipaa/for-professionals/privacy/laws-regulations/index.html>

regulating how online services such as web sites collect and use minors' personal data and information.¹² Minors are defined as those under thirteen years of age. At the time of the cases in this dissertation, COPPA's personal information included names, physical and Internet Protocol addresses, online contact information such as user name, Social Security and telephone numbers, and photographs containing a minor's image.¹³ COPPA applies only to companies offering an online service for profit. Individuals, including minors' parents, have the right to review the information provided to and collected by covered online services. Online services are obligated to comply with all COPPA requirements, including but not limited to making a privacy policy publicly available stating how it complies with COPPA. Online services must obtain parents' consent before collecting information from minors, may not condition minors to disclose additional information via games, and must protect collected information. COPPA faced opposition when adopted, specifically for the high costs necessary to comply with required obligations and challenges securing parental consent. (Matecki 2010)

In addition to the United States federal government, the state of California regulates the collection and use of personal data. Of note for this study, in 2003 the state adopted the Online Privacy Protection Act (OPPA). OPPA regulates commercial online services that collect personal data from California residents.¹⁴ Such data includes first and last name, physical address, email address, Social Security and telephone numbers, and any other personal identifiers. OPPA applies to all companies offering for-profit services to California residents, including those companies based outside the state and country. Companies are obligated to publicly post a privacy policy disclosing what and how they collect and use individuals' personal data. OPPA is distinct from the earlier-detailed regulations in the United States because it does not assign specific rights to individuals, such as the right to view their collected data or amend their data if deemed inaccurate.

The Regulations hypothesis proposes that the key determinant of product teams' responses to their uncertainty is their interpretation of the relative importance of regulations regarding the collection and use of personal data. As detailed earlier in this section, those regulations varied in their specificity and scope, potentially impacting product teams' responses in different ways. From the outset European regulations defined personal data, individuals' rights regarding their data, and organizations' obligations when collecting that data. (Cate 1999) Regulations in the United States focus less on individuals' rights and more on government agencies' activities, potentially leaving industry and the market to determine what obligations must be fulfilled in order to collect and use personal data. Just as the regulations vary, product teams' interpretation of those regulations may vary as well, potentially leading to different ecosystem designs. Assessing evidence for this hypothesis will reveal under what circumstances and how these varying regulations impacted product teams' data ecosystem design decisions.

¹²Children's Online Privacy Protection Rule. 16 CFR Part 312. <https://www.ftc.gov/enforcement/rules/rulemaking-regulatory-reform-proceedings/childrens-online-privacy-protection-rule>

¹³In 2012 COPPA was amended to cover new forms of personal information, including but not limited to geolocation information and audio and video recordings.

¹⁴California Business & Professional Code Section 22575.

For the Regulations hypothesis to be supported, readers should observe the following evidence in the cases. Product teams will seek and find regulations relevant to their proposed personal data collection and use activities. The product team will then modify the design of their data ecosystem based on their interpretation of the relative importance of those regulations. For example, if the product team interprets that regulations stipulate that users be able to access their collected data, the product team will modify their data ecosystem design in order to comply with those regulations. Without this regulatory requirement the product team would not have designed the data ecosystem to distribute data to users in this way.

The Regulations hypothesis serves as the second candidate explanation for product teams' responses to their uncertainty. At this point readers will observe that the Regulations hypothesis does not reference the concept of social license, which was introduced in Chapter 1: Introduction. This is not an oversight, rather a deliberate decision because social license is an outcome from a process. To secure social license, a company engages with stakeholders to identify the terms through which it may operate, and then fulfills those terms. (Gunningam et al. 2003) Myriad forces, such as economics and user needs as featured in this dissertation, impact the terms of a company's social license. Regulations are another force impacting social license, but not necessarily the key force nor must they be fulfilled to secure social license. For example, online transportation network company Uber openly flouts regulations, but has secured its social license to operate through fulfilling users' transportation needs. The social license concept is revisited in depth in Part Three of the dissertation, where the reader will learn about the relationships between product teams' data ecosystem designs, their respective social license terms, and value creation.

2.4 User Needs

The User Needs hypothesis proposes that the key determinant of product teams' responses to their uncertainty is their interpretation of the relative importance of user needs. The theory is that product teams address their uncertainty regarding designing the data ecosystem by interacting with users to gather and understand their needs, then designing the instrumented fitness experience and its data ecosystem to fulfill those needs. This section details the concepts underlying this hypothesis, drawing on the fields of user-centered design, product management and marketing, and innovation.

In the mid-1980s researchers in the human computer interaction field proposed that technology designers should pursue a strategy of user-centered design. These proponents argued that technology should ultimately serve the user by fulfilling their needs. (Gould and Lewis 1985; Norman and Draper 1986) Product designers should "ask what the goals and needs of the users are, what tools they need, what kind of tasks they wish to perform, and what methods they would prefer to use." (Norman and Draper 1986) With this knowledge designers develop an understanding of the user experience: what users really want and need, how they work or would like to work, and how they mentally envision their domain. (Baxter,

Courage, and Caine 2015)

Product and service design teams pursuing a user-centered design strategy typically iteratively engage with users in a multistep process. While the number of steps may vary, the sequence of steps is as follows. (Baxter, Courage, and Caine 2015; Kuniavsky, Goodman, and Moed 2012) First, design teams consult users to understand the user experience, including users' needs and goals. The team analyzes those experiences and converts them into requirements, the specific features and functionality the product or service must provide users as part of the user experience. The team creates a prototype product or service, which is then evaluated by users to see if it fulfills their needs. This process of creating, evaluating, and revising repeats until user needs are fulfilled, at which point the product or service is released to the market.

Proponents of user-centered design argue that designing technologies to focus first and foremost on fulfilling user needs offers multiple benefits to a technology development organization. (Baxter, Courage, and Caine 2015) Fulfilling these needs increases sales due to increased customer satisfaction. Technology development time is reduced because products and services contain desired and necessary features. Closely engaging with users with this iterative process reduces the risk that the released product or service does not fulfill users' needs. Lastly, by understanding user needs companies will identify new opportunities for product and service innovation.

User-centered design poses challenges for companies, as user needs may not align with business needs. For example, users may desire features and functionality that are not in the company's financial interest. The company may try to appeal to too many different types of users, potentially diluting their ability to fulfill the needs of any single user type.

Product teams face a key decision of whose user needs they seek to fulfill with their product. This decision is key because different types of users have different types of needs, and fulfilling those needs may require differing features. Product teams have finite resources, and as such must determine what types of users they will engage with during the user-centered design process, and ultimately whose needs their product will fulfill.

Researchers have found that marketplaces for products feature five key types of users (Moore 2014; Rogers 2010). Each of these user types adopt a product at different times in the product's lifecycle, from its earliest to later stages. Innovators are those users who are the very first to use a product, willing to take risks with new products, have high social status, are financially well-off, and are often socially associated with those developing new products. Early adopters are willing to take on lesser risks with new products, while still being amongst the first to adopt a new product. Next, early majority users are characterized as pragmatic, waiting until a product is adopted by others in their community. Late majority users are skeptical of new products, and less willing to take on the risk of adopting those products until much of the marketplace has adopted the product. Laggards are those who are last to adopt a product, and are characterized as highly risk-averse, financially challenged, and only adopt the product when nearly all other users have adopted the product. Product teams position their product to appeal to one more of these five user types in the marketplace. (Moore 2014) Teams developing pioneering products, such as the instrumented fitness experiences

in this dissertation's cases, strive to position their products for innovators and early adopter users so that they may then attract the larger groups of early majority and later-adopting users. (Moore 2014)

Around the same time user-centered design emerged, corporate innovation researcher von Hippel proposed that companies developing first of their kind products pursue a lead user methodology. (von Hippel 1986) Lead users are characterized as those individuals currently facing needs that will later become widespread in the marketplace, and will benefit from finding a solution to their needs. These individuals may craft and develop their own solutions, even if they are not trained in product development. Similar to user-centered design, von Hippel's methodology focuses on finding and closely engaging with these lead users in order to incorporate their innovations in early product designs, and then developing and releasing products to fulfill their needs. The company may then experience a first-mover advantage, where they are the first to release a product meeting needs that later become widespread in the marketplace. Numerous studies and reports convey companies' successes with lead user innovation efforts, including at 3M, Hilti, and the LEGO Group. (Herstatt and von Hippel 1992; von Hippel, Thomke, and Sonnack 1999; Weckstrom 2009)

It should be noted that Rogers and Moore's innovator and early adopter user types and von Hippel's lead users appear to be similar, however they feature marked differences. Rogers and Moore consider risk tolerance, and financial and social status in their definitions, while von Hippel makes no such distinction. Rogers and Moore's innovator users are not developing their own solutions to meet their needs, one of the primary characteristics of von Hippel's lead users.

Product teams' awareness of these differences is critical, because their interactions with each during the product development process offer different affordances. Lead users frequently bring a combination of technical and domain expertise to the product development process, and propose ideas that challenge companies' existing product strategy. (Magnusson 2009) Lead users can more readily identify a user need and assess the feasibility of fulfilling that need. Non-lead users do not have such technical and domain expertise, and are therefore seen as a better source for identifying user needs. (Magnusson 2009)

Whether interacting with lead or non-lead users, product teams are presented with a choice regarding the embeddedness of those users during the product development process. Lead and non-lead users may be outside the product team and company, such as members of the general public. Alternatively users may be part of the team or company itself. Turning to internal, embedded users reduces the risk that others, such as competitors, learn about the product under development. Researchers have found that embedded lead users, those inside a company who are developing their own solutions to meet personal needs well before the market, present additional advantages. (Herstatt, Schweisfurth, and Raasch 2016; Schweisfurth 2012; Schweisfurth and Raasch 2015) Embedded lead users are found to be more customer-oriented and able to combine their user and employee knowledge. Embedded lead users can identify user needs and assess the ability of the product team and company to fulfill those needs. (Schweisfurth 2012; Schweisfurth and Raasch 2015) Embedded users may use their position on the team or in the company to over-influence product strategy,

introducing the risk that the product fulfills their needs and not those from a broader set of external users. These concerns may be mitigated through a hybrid model of interacting with both internal and external users.

As noted earlier in this section, product teams pursuing a user-centered design strategy iteratively interact with users throughout the multistep product development process. (Baxter, Courage, and Caine 2015; Kuniavsky, Goodman, and Moed 2012) Team members may interview users, posing questions about users' activities and attitudes that may elicit insights into their needs. Observing users, whether in their everyday environment or in a simulated setting, may provide further insights into their behaviors. Team members may conduct diary studies, where users log their activities and attitudes in a journal. Team members then review those diary entries, or use them as part of interviewing users about their needs. Product teams can hold workshops with lead users to generate new product concepts. (Churchill, von Hippel, and Sonnack 2013) Multiple lead users are brought together with the product team to share their individual user needs, discuss solutions, and refine selected solutions into product concepts. Participants may prototype and evaluate solutions themselves during the workshop. Research has found that such workshops generate new product concepts faster than other methods. (Herstatt and von Hippel 1992) Interacting with users in multiple and varied means presents product teams with the opportunity to more deeply understand those users' experiences and needs.

In summary, the User Needs hypothesis proposes that the key determinant of product teams' responses to the uncertainty is their interpretation of the relative importance of user needs. Product teams gather those user needs through interacting with one or more user types, who may be embedded within or outside the product team or company. Assessing evidence for this hypothesis will reveal which type or types of users product teams targeted for their instrumented fitness experience, how teams interacted with those types of users, the needs of those users, and how the teams interpreted and prioritized the fulfillment of those needs in the data ecosystem design.

Readers should observe the following evidence supporting the User Needs hypothesis. Product teams will interact with one or more user types to understand their needs. The product team will then modify the design of the data ecosystem based on their interpretation of the relative importance of those needs. As noted earlier, fulfilling a user need may conflict with the company's interests. For example, users may desire access to their collected data. Designing the data ecosystem to support this need would lower users' switching costs, easing their ability to adopt a competing product. The product team's decision to fulfill this need in light of the economic downside is supporting evidence that the team's interpretation of the relative importance of user needs is a key determinant of the data ecosystem design.

As an example of non-supporting evidence, users may desire that the data ecosystem collect certain personal data, which based on the team's interpretation of the relative importance of regulations is prohibited. The team's decision to not fulfill this user need is supporting evidence that the team's interpretation of the relative importance of regulations is a key determinant of that aspect of the data ecosystem design, not its interpretation of the relative importance of user needs.

2.5 Team Expertise

The Team Expertise hypothesis proposes that the key determinant of product teams' responses to their uncertainty is their interpretation of the relative importance of their internal expertise, the knowledge they have acquired through prior experiences. A product team that deems itself expert, such as in certain domains or with certain technologies, leverages that expertise to design the data ecosystem itself. As a counter-example, a non-expert product team turns to outsiders for needed expertise, incorporating those outsiders' contributions in the data ecosystem design. The Team Expertise hypothesis draws on innovation theory, and its concepts of closed innovation and various types of open innovation, from management science.

Innovation is the process of developing new products and services. (Chesbrough 2006; Rogers 2010) The product teams featured in this dissertation are engaged in innovation, as they are creating instrumented fitness experience technologies for the consumer market. Companies and teams developing new products and services face a key decision regarding whether they should pursue a closed or open innovation strategy. (Chesbrough 2006) As detailed below, the decision stems in part from teams' assessment of their expertise. The decision is key because it impacts how the product or service creates value and for whom.

Closed innovation is the process of creating new products and services entirely within a company. (Chesbrough 2006) Companies pursue a closed innovation strategy because they perceive that their employees have, or can best develop, the expertise needed for their innovation. That expertise is viewed as intellectual property, which these companies believe is best monetized through enacting tight control over its distribution. These companies do not share this expertise with others, such as in the form of licensing resulting technologies to other companies for their own products and services. With closed innovation a company leverages its expertise to create value for itself and users, and not other companies who could use that expertise to create additional value.

Much of innovation by large companies in the United States following World War II and through the 1970s is characterized as closed innovation. (Chesbrough 2006) Companies such as AT&T, Lockheed, and IBM formed internal research and development groups to create and amass expertise. These companies envisioned this expertise as intellectual property, which they then protected with patents. Expertise was also used to create new products and services for the company. Less is known about innovation practices by small and medium-sized businesses during that time, though researchers are exploring their contemporary efforts. (Brunswick et al. 2014; Lee et al. 2010)

Open innovation is the process by which companies use internal and external knowledge to create news products and services. (Chesbrough 2006) Companies pursuing open innovation purposefully exchange knowledge and expertise with one another, where those exchanges may be characterized as pecuniary, for a fee, or non-pecuniary. (Dahlander and Gann 2010) As detailed below, those exchanges are further characterized as transferring knowledge into or out of a company. (Gassmann and Enkel 2004)

In the case of the latter, referred to as inside-out or outbound open innovation, a company

with expertise it believes other companies may value makes that expertise available to those other companies. (Gassmann and Enkel 2004) Making that expertise available for free is noted as a Revealing strategy, while making it available for a fee is referred to as a Licensing strategy. (Dahlander and Gann 2010) Companies may pursue inside-out open innovation when they perceive they are not positioned to create value with that expertise themselves, such as due to the costs of bringing the innovation to market itself.

Examples of the Revealing and Licensing strategies can be found in the pharmaceutical industry. Drug manufacturers Novartis Pharma and GlaxoSmithKline pursued a Revealing strategy by sharing their expertise regarding specific drugs they had developed with the broader research community. (Brunswick et al. 2014) Through relaxing control over their patents the company sought to help the community understand related diseases. Pfizer and Roche develop and bring to market new drug treatments, some of which they then license for a fee to other companies. (Gassmann and Enkel 2004) These other companies then develop new uses for those drug treatments, such as treating other ailments. By pursuing the Licensing strategy Pfizer and Roche earn a royalty for sharing their expertise to these other companies.

With outside-in or inbound open innovation, a company taps others' expertise for its own development efforts. (Gassmann and Enkel 2004) Companies pursue outside-in innovation when they perceive they do not have the needed expertise or do not have the time or skills to develop that expertise internally. (Chesbrough 2006) As with inside-out innovation, outside-in innovation may be either non-pecuniary or pecuniary. (Dahlander and Gann 2010) Both are described below with examples.

With the Sourcing model of outside-in innovation a company looks to its external environment for freely available expertise that it may then apply to its development efforts. (Dahlander and Gann 2010) Companies may pursue this strategy because it does not incur direct development costs, however the company may incur costs searching for and vetting relevant expertise. The strategy poses risks for companies, as the expertise they source is also available to other companies. Those other companies may use that freely available expertise to create their own value, potentially in direct competition with the company pursuing the Sourcing strategy.

Examples of the Sourcing model of outside-in innovation abound in the technology industry. Numerous companies have developed new products based on Linux, the computer operating system created by Linus Torvalds and others in the early 1990s. (Weber 2004) As an open source technology, expertise regarding what and how the operating systems works is available to the public in online forums and mailing lists, and the source code itself is available in online code repositories. Companies may freely tap this expertise for their own innovation efforts, as well as integrate source code from the operating system in their products. Throughout the mid-1990s to today companies have used Linux as the foundation for commercial products. Caldera and Red Hat packaged the operating system with training and support, and sold the system and services to other companies. (Weber 2004) Google's Android and Chrome operating systems are built atop Linux, and can be found in

commercially available mobile computing devices.^{15,16}

The Acquiring model of outside-in innovation features the exchange of money for external expertise. (Dahlander and Gann 2010) Companies developing new products pursue this strategy because they seek greater control over their needed expertise and the ensuing value that can be created with that expertise, than with the Sourcing strategy. With the Acquiring model companies negotiate the terms for how value is created with that expertise. For example, the sourcing company may enter an exclusive agreement with the source of that expertise, mitigating the risk that it is used by other companies to create competing offerings. The sourcing company may seek to completely control how value is created with that expertise by outright acquiring the source of expertise and integrating the company and that expertise into its innovation efforts. The Acquiring model presents companies with the opportunity to enact controls over the creation of value by that expertise.

Apple's development of the original iPod is an example of the Acquiring model. In early 2001 semiconductor company PortalPlayer was developing a prototype portable music player.^{17,18} PortalPlayer planned to monetize their efforts through securing licensing agreements with Teac, IBM, and other companies, who would then build and sell their own branded music devices. Referring to the innovation strategies detailed earlier, PortalPlayer was pursuing an outbound open innovation Licensing strategy. An Apple product team working on a portable music player identified that it did not have the needed expertise and was not willing to spend the time developing that expertise internally. The team saw that PortalPlayer had developed both the needed hardware and software. Apple paid PortalPlayer for exclusive rights to the technology, preventing Teac, IBM, and others from continuing to use the technology. Apple continued developing the technology to become the iPod, and paid PortalPlayer royalties for every iPod sold.

In summary, the Team Expertise hypotheses proposes that the key determinant of product teams' responses to their uncertainty is their interpretation of the relative importance of their expertise, the knowledge they have acquired through prior experiences. An expert product team will address their uncertainty regarding designing the data ecosystem by relying on its expertise, pursuing in effect a closed innovation strategy. A product team that deems itself non-expert will pursue either a Sourcing or Acquiring outbound-in open innovation strategy. Assessing evidence for this hypothesis will help reveal how and why product teams' data ecosystem designs feature the contributions of other companies, such as those providing data collection sensors or analysis.

Supporting evidence for the Team Expertise hypothesis will take the following forms in the cases. A product team will assess its expertise regarding aspects of the data ecosystem,

¹⁵Google. Platform Architecture. <https://developer.android.com/guide/platform/index.html>

¹⁶The Chromium Projects. Kernel Design. <http://www.chromium.org/chromium-os/chromiumos-design-docs/chromium-os-kernel>

¹⁷Kahney, L. Inside Look at Birth of the iPod. *Wired*. July 21, 2004. <http://archive.wired.com/gadgets/mac/news/2004/07/64286>

¹⁸Sherman, Erik. Inside the Apple iPod Design Triumph. *Electronics Design Chain*. Summer 2002. <http://web.archive.org/web/20051030080641/http://www.designchain.com/coverstory.asp?issue=summer02>

including the collection and analysis of data, and the distribution of data and information. A product team that is not expert regarding specific aspects of the data ecosystem design will rely on other companies' expertise to fulfill those aspects of the data ecosystem design. The team may pursue a Sourcing or Acquiring strategy to integrate that expertise in the ecosystem design.

2.6 Conclusion

This chapter detailed the four hypotheses explaining pioneering product teams' decisions regarding the design of the data ecosystems for their instrumented fitness experiences. These hypotheses include: Information Economics, Regulations, User Needs, and Team Expertise. Each hypothesis is deduced from a body of theory. With this review readers are prepared to analyze the three case studies for the presence and impact of these forces, and identify supporting and countering evidence for the four hypotheses.

Chapter 3

Empirical Study Design

3.1 Introduction

This dissertation applies a structured focused comparison case method to explain pioneering product teams' responses to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences. The research was conducted with approval for human subjects research from the Committee for the Protection of Human Subjects at the University of California, Berkeley, protocol number 2012-10-4681.

The case study method was chosen because it presents the opportunity to holistically examine a phenomena: how and why an individual or organization engaged in processes or activities over a specific period of time. (Yin 2013) A multiple-case comparison method was selected in order to identify and assess differences within and across cases of the phenomena. (Baxter and Jack 2008, Creswell 2013, George and Bennett 2005, Yin 2013), and to address potential issues of bias and over-generalization associated with single-case studies. (Creswell 2013; George and Bennett 2005) The structured focused comparison method was chosen because it offers a framework to iteratively pose standardized questions to cases in order to identify explanatory factors, which can then be assessed to create cumulative knowledge regarding the phenomena. (George and Bennett 2005)

Given their focus on specific phenomena, case study methods inherently limit their representativeness of broader phenomena and the generalizability of findings to other phenomena. (George and Bennett 2005; Yin 2013) This limitation is unavoidable. This dissertation and its findings make no claims of applicability to disparate phenomena, though the findings may be used to inform questions that may then be posed to unique studies of other phenomena.

This study features three cases: the Suunto T6 of 2004, Garmin Forerunner 50 of 2007, and Adidas miCoach Pacer of 2010. The decision to feature three cases, and these three instrumented fitness experiences, is a product of the research objective, case selection criteria, and balancing tradeoffs regarding resources and desired generalizability.

The objective of this research is to identify the range of explanatory factors contributing to pioneering product teams' varying designs for their instrumented fitness experiences' data

ecosystems. Achieving that objective requires multiple cases, as increasing the number of cases serves to broaden the range of possible explanatory factors and varying data ecosystem designs.

Cases were selected according to the release date and location of the instrumented fitness experience featured in the case. Since this study sought to understand pioneering teams' efforts, when as described in Chapter 1: Introduction they operated under the greatest uncertainty, it was determined that cases would feature release dates during the initial emergence of instrumented fitness experiences. An extensive review of the domain was conducted by searching the Internet for product reviews of early instrumented fitness experience technologies.¹ The search found that the Suunto T6 of 2004 was the first, if not at least amongst the first, instrumented fitness experiences publicly released matching the definition in Chapter 1: Introduction.

Public release dates for additional candidate cases were varied in order to reduce potential selection bias to a technological or regulatory era. For example, an instrumented fitness experience released in 2007 may be subject to regulations that did not exist in 2004. Distributing release dates would further broaden the range of possible explanatory factors for product teams' decisions regarding designing their data ecosystems. That decision posed a tradeoff regarding case independence: a second case's product team decisions may be informed by its' reactions to decisions made by the prior case's product team. Likewise for the third case product team reacting to the earlier cases. This concern was mitigated during the analysis phase with process tracing. (George and Bennett 2005)

Cases were selected based on their release location, as technologies inside and outside the United States are subject to varying legal regulations with regard to collecting and using personal data. These regulations are detailed in Chapter 2: Guiding Concepts. Selecting at least one case featuring an instrumented fitness experience released outside the United States might reveal differences regarding the role of regulations in shaping product teams' decisions.

Given these release date and location criteria, the study required a minimum of two cases: one case featuring an instrumented fitness experience released early in their emergence and a second case featuring a subsequent release date, with either of the cases released outside the United States. A third case was added to potentially reveal additional rival explanatory factors and to strengthen the certainty of the findings. (Yin 2013)

Drawing on the pool of candidate cases described earlier, it was found that the Suunto T6 fulfilled both the release date and location criteria. The Suunto T6 was released early, if not earliest in instrumented fitness experiences' emergence, and was released throughout the world, not just the United States. Selecting the Suunto T6 of 2004 narrowed the candidate case pool to those released post-2004. Of the remaining candidates, the Garmin Forerunner

¹This search generated a pool of candidate cases including but limited to: Adidas miCoach Pacer, Basis B1, Fitbit Tracker, Garmin Forerunner 50, Jawbone UP, Magellan Switch, Misfit Shine, Motorola MO-TOACTV, Nike FuelBand, Pebble watch, Polar 625X, Suunto T6, Timex Bodylink, UnderArmour Armour 39, and Withings Pulse. Each candidate case's release location was also noted in order to guide further case selection.

50 was selected due to its' 2007 United States-oriented release, and because a key member of the product team was known from participating in the prior exploratory study of instrumented experience technologies. Of the remaining candidates, the Adidas miCoach Pacer was selected due to its 2010 global release.

This case selection criteria raises the concern that the study features those instrumented fitness experiences successfully released to the public, omitting the potentially valuable perspectives of product teams who attempted and failed to release instrumented fitness experiences. Such a perspective could be gathered, but not without significant efforts identifying such unreleased instrumented fitness experiences and persuading respective product team members to discuss their failures. Opting not to include unreleased instrumented fitness experiences limits the generalizability of the study's findings, but is a reasonable tradeoff given the noted challenges.

3.2 Data Sets

Case studies call for extensive, detailed, and diverse data in order to support in-depth understanding. (Creswell 2013) This study's objective of understanding product teams' decisions designing the data ecosystems for their instrumented fitness experiences called for two forms of data: artifacts depicting the data ecosystem itself, such as what and how it collected and distributed users' data, and the perspectives of product team members who made decisions regarding the data ecosystem design. Pairing these data for each case would support a richer and deeper understanding of product teams' decisions regarding the design of their data ecosystems.

Each case is based on a pair of data sets: a collection of public artifacts related to the instrumented fitness experience and its data ecosystem design, such as user manuals, privacy policies, and marketing literature, and interviews with key decision makers who were members of the product team responsible for bringing the instrumented fitness experience to market. Interviews with key decision makers could contextualize the design of the data ecosystem for the instrumented fitness experience, as conveyed in the public artifacts, as well as elicit ecosystem designs that were considered and not pursued. Interviews would further illuminate why certain designs were chosen or not.

Public Artifacts

Each case's artifacts data set is composed of publicly available artifacts related to the instrumented fitness experience. Artifacts originate from the companies providing the instrumented fitness experiences, such as press releases, user manuals, terms of service, privacy policies, and technical documentation. Additional related regulatory artifacts, such as regulations regarding the collection and use of personal data, originate from government bodies in the regions where the instrumented fitness experience was released.

Using public artifacts presents several opportunities to strengthen the research. The artifacts convey the company's perspective regarding the design of the instrumented fitness experience's data ecosystem, including its supported features and functionality. Regulation-related artifacts convey national regulators' perspectives regarding the personal data these experiences collect and analyze. Both types of artifacts are public manifestations of companies' and regulators' decisions regarding personal data and data ecosystems.

Utilizing public artifacts strengthens the dissertation's reproducibility and reliability. Subsequent studies could collect these and similar artifacts, whether focusing on instrumented fitness experiences or other forms of personal data-oriented technologies. Those artifacts could then be analyzed with the same techniques detailed later in this chapter.

Relying on public artifacts poses a number of limitations, as the artifacts may be biased to present a certain message. (George and Bennett 2005) Artifacts oriented towards sales and marketing are created to spur public interest and drive sales of the instrumented fitness experience. Such concerns are mitigated by introducing documents with differing and countering bias, such as legal-oriented artifacts oriented toward protecting the company. Public artifacts do not provide insight into how or why product teams made the decisions that manifest in the design of the data ecosystem; this limitation is addressed by interviewing decision makers on the product teams. Such triangulation within and amongst data sets is key to strengthening a case study's construct validity, which is the consistency and accuracy of findings. (Yin 2013)

The data set of public artifacts for each case includes at a minimum the instrumented fitness experience's launch press release, user manual, privacy policy, terms of service, retail product packaging, and related national regulations for the case product's release. Additional artifacts vary by case and are grouped by type. The public artifacts data set for each case is presented in Table ?? Public Artifacts Data Sets on page ??.

Key Decision Maker Interviews

Each case's key decision maker interview data set includes multiple semi-structured interviews with the key decision makers on the product team responsible for conceiving of and bringing the instrumented fitness experience to market. These interview data sets served to contextualize the public artifacts data sets and illuminate product teams' data ecosystem design decision making processes.

A key decision maker is defined for this study as an individual responsible for defining the features and functionality for the instrumented fitness experience, particularly with respect to the design of its data ecosystem. This definition arose from personal experience in the technology industry, where such decisions were made as a product manager. A review of information technology product development literature further contributed to this definition. (Chesbrough 2006; Eppinger and Ulrich 2015)

Interviews ranged from 50-90 minutes, during which interviewees were posed the same set of semi-structured questions (detailed in the Appendix: Interview Guide). The selection of questions was informed by findings from a prior exploratory study of instrumented

Table 3.1: Public Artifacts Data Sets

Class	Suunto T6	Garmin Forerunner 50	Adidas Pacer	miCoach
General	press release user manual privacy policy terms of service product packaging	press release user manual privacy policy terms of service product packaging	press release user manual privacy policy terms of service product packaging	
Regulatory	Finnish Personal Data Law of 1999	Children’s Online Privacy Protection Act of 1998 California Online Privacy Protection Act of 2003	German Federal Data Protection Act of 2009	
Product	Training Guidebook Membership Agreement Registration Page	Registration Page Quick Start Manual Getting Started blog	Connect insert card How the Zones Work blog post	
Support	registration help	Support forum Coaching Philosophy	How to Export Data?	
Marketing	launch video team interview product web page	product web page commercial	YouTube video	
Developers		API documentation release notes See the Code Technical Jazz UI Library API License Agreement		
Total	30	56	22	

experiences in the automotive, fitness, and entertainment domains. Of note in that study, companies encountered challenges in several areas: overcoming the technical complexities of collecting and analyzing new forms of personal data, securing social license for their instrumented experiences, and understanding the evolving regulatory landscape’s impact on those experiences. The study found that companies addressed these challenges in part by interacting with users, outside companies, regulators, and others with a stake in the instrumented experience. This dissertation first sought to continue this line of inquiry, with the goal of understanding how and why product teams interacted with these stakeholders during the development process. Very early in the interview data collection process this goal evolved to a broader understanding of product teams’ activities during the development process, and

not just their interaction with stakeholders. As described later in this chapter, themes from the exploratory study’s findings served as the foundation for identifying the explanatory factors for product teams’ data ecosystem-related design decisions.

While the goal of the study evolved, the interview questions themselves did not need to evolve as well. From the outset, interview questions were meant to collect a broad understanding of the perspectives and experiences of key decision makers on product teams. Interviewees were asked about their role developing the instrumented fitness experience, the makeup of the product team that created the experience, the state of the instrumented fitness experience market at the time, and the company’s interactions with users and outsiders, including regulators and other companies, while developing, when releasing the experience to the market, and after its release. Interviewees were asked to note when those interactions were public or private, and to explain why. All interviewees were posed the same suite of questions.

The key decision maker interview data sets for each case are presented in Table ?? Key Decision Maker Interviews Data Sets on page ??, including the interviewee’s self-reported title while a member of the product team developing and releasing the instrumented fitness experience. As noted earlier, one Garmin Forerunner 50 interviewee participated in the prior exploratory study. The participant’s comments from that study are not included in this study’s data set, as the questions posed and the timeframe discussed were markedly different.

Table 3.2: Key Decision Maker Interviews Data Sets

Case	Interviewee Title
Suunto T6	T6 Product Manager
	T6 Project Manager
	Lead Software Engineer
	Head of Consumer Software Applications
Garmin Forerunner 50	Product Manager, Garmin Fitness
	Head of Product Management, Garmin Connect
	Head of Engineering, Garmin Connect
	Vice President of Personal Monitoring, Dynastream
	Software Engineer, Garmin Training Center
Adidas miCoach Pacer	Team Lead, Adidas Innovation Team
	User Experience Designer, Adidas Innovation Team
	Account Manager, Molecular
	Engineering Leader, Molecular
	User Experience Leader, Molecular
	Program Manager, Molecular
	Interaction Designer, Molecular

Interviewees’ self-reported title and product team role information was verified by check-

ing their profiles on the business network site LinkedIn, and searching the Internet for company press releases, interviews on product review and media sites, and related patent applications and awards. Triangulating amongst these resources helped affirm that interviewees were members of the product teams, and that they held key decision making responsibilities.

The interviewee data set is subject to certain limitations and caveats. Interviewing subjects about past events poses challenges, as interviewees may not recall critical details or be susceptible to hindsight bias. (Creswell 2013) Potential recall issues were addressed by priming interviews' memories of the product and timeframe we would discuss. Each interviewee was provided with a single page document displaying the instrumented fitness experience and its key features as identified in the corresponding public artifacts data set's product launch press release. The document also depicted a prior and subsequently released related product by the company in order to help the interviewee recall the time. The document was distributed via email to all interviewees in the days before an interview. Interviewees' memories were further primed by displaying and sharing the instrumented fitness experience itself, including its product packaging, the device, and accessories, during interviews. Interviewees were requested to note when they did not remember details of an event, and to not speculate about those details.

Bias poses a challenge for interviews, as interviewees may present themselves, their company, colleagues, or a decision in a certain light. Such bias was countered through interviewing multiple team members in varying roles, and comparing interviewees' comments with fellow interviewees' and the public artifacts data set. Discrepancies in interviewees' perceptions of events are noted in the case studies.

3.3 Data Collection

Data was collected for each case between August 2015 and August 2016. A data collection protocol guided these efforts in order to better ensure that each data set featured a similar set of artifacts and interviewees. The protocol outlined the key artifacts needed for each case, including the earlier-noted instrumented fitness experience's launch press release, user manual, privacy policy, terms of service, retail product packaging, and related national regulations for the case company's and released product's locations. The protocol also detailed the criteria and process for identifying and recruiting key decision makers for each case.

Public Artifacts

Each case's public artifacts data set was collected from the Internet via the Internet Archive's Wayback Machine, which stores archived copies of public web pages.² The Wayback Machine was used to navigate each case company's web site on the exact date the instrumented fitness experience was publicly released or closely thereafter. This date was chosen in order to

²Internet Archive: Wayback Machine. <https://archive.org/web/>

collect a record of the company's public communications regarding the instrumented fitness experience once it was available to the public.

The following artifacts were collected from each instrumented fitness experience's respective web site: its launch press release, user manual, privacy policy, terms of service, as well as product-oriented marketing pages describing features and functionality. Each site was then navigated to discover other artifacts, such as customer support forums and postings, product demonstration videos, company histories, developer documentation, and lists of frequently asked questions. Each of these artifacts were saved with Evernote, a browser and desktop computer software tool for collecting and organizing electronic documents.

Each instrumented fitness experience's retail product packaging artifacts were gathered by purchasing the products when possible. New in box versions of the Garmin Forerunner 50 and Adidas miCoach Pacer were acquired from Amazon and eBay, respectively. A complete Suunto T6 was not found, so in lieu of the physical packaging the Wayback Machine was used to navigate archived news media and product review sites to find images of the T6's box and contents. These images were saved to Evernote.

Regulatory-related public artifacts were identified by reviewing privacy policy and terms of service artifacts for references to such regulations. Reviewing the history of personal data regulations in the United States and internationally as documented in the law and policy research community also revealed relevant regulatory artifacts. Interviewees also referenced relevant regulations. These regulations were then gathered from government web sites and saved to Evernote.

This method of collecting public artifacts with the Wayback Machine and Evernote presented affordances and challenges. Each collected artifact was publicly accessible to other researchers, supporting the reproducibility of my data collection method. The Wayback Machine did not fully archive Adidas' web site during the miCoach Pacer era, resulting in fewer artifacts to collect and analyze. Fortunately the required artifacts needed for the case were archived. The Wayback Machine's lack of archiving artifacts may limit the extensibility of this research, as artifacts for other instrumented fitness experiences may not be able available to researchers. In such situations the researcher may need to contact the companies for needed artifacts.

Key Decision Maker Interviews

Each case's key decision maker interview data set was collected between September 2015 and August 2016. Interviewee identification and recruiting began in August 2015 alongside the public artifact data set collection. Potential interviewees were identified by keyword searching multiple public Internet data sources, from Google's search site to LinkedIn, Google Patents, and YouTube. Keywords included the company name, instrumented fitness experience name, and product team roles. Searching these sites revealed numerous potential interviewees, for each of which a digital dossier was created containing each interviewees' Internet-based LinkedIn profile page, social media accounts, and social networking profile. Each dossier

was analyzed to assess the candidate interviewee's role in the product development process during the instrumented fitness experience's development timeframe

Interviewees were recruited via electronic mail messages sent from my account at the School of Information at the University of California, Berkeley, and via the snowball recruiting method. The message contained a request for a sixty to ninety-minute interview about their past experiences bringing the specific instrumented fitness experience of study to market. The interview would be published as part of a case study detailing the development and release of the experience and be included in a public dissertation. Candidates were informed that their company name and product name would be revealed, but not their name unless they chose to. Interviewees were not recruited via LinkedIn's message features or social media, as such methods could potentially compromise interviewee privacy.

Interviewees were also recruited via the snowball method, where interviewees were asked if they could recommend other interviewees that could inform the study. (Creswell 2013) In such cases interviewees were provided with an email that they could privately forward to that potential interviewee if they so desired. The email contained a study overview and the researcher's contact information. This method was used in order to protect potential interviewees' privacy.

Interview data was collected once in-person, while all others took place via Skype video or audio-only telephone calls. All interviewees were provided an overview of the study, asked for their consent to participate in the study, and informed that they could terminate the interview at any time. Interviewees were shown the boxed instrumented fitness experience, when available. Interviewees were posed the same set of semi-structured questions described earlier and noted in the Appendix: Interview Guide. Interviews ranged from 50 to 90 minutes, and were video and/or audio recorded and transcribed.

Collecting interview data via these techniques presents opportunities and challenges. The interview guide offered a means to more reliably collect data that could then be compared within and amongst each case's interviewees. Relying on LinkedIn and other public sources as a resource for identifying interviewees potentially limited the pool of candidate interviewees. Some may not have LinkedIn profiles or clearly describe their role, title, or responsibilities in a way that can be found via a search engine. This concern was mitigated by searching other public Internet sources and using the snowball method.

3.4 Data Analysis

Between October 2015 and November 2016 each case data set was analyzed with a multistep process. Interviews were transcribed and reviewed to ensure each interviewee answered every question posed in the interview guide. The public artifacts were coded within Evernote by applying text-based tags to each saved artifact in the data set, while interview transcripts were coded with MAXQDA12 qualitative data analysis software. Ideally one software-based tool would have been used to code each case data sets, however the myriad forms of artifacts pushed the technological limits of MAXQDA12 and competing coding software tools. Given

the relatively small number of transcripts and artifacts in the data sets, managing two analysis systems did not prove difficult.

Each case data set was coded in three rounds, with different coding techniques applied in each round. Codebook excerpts are presented in the Appendix: Code Book Excerpts. Exploratory-oriented descriptive coding was used to become familiar with the data. With descriptive coding the researcher codes documents and transcripts based on their topics. (Saldana 2012) Transcripts were coded for interviewees' roles and responsibilities and the make up of the product team that brought the instrumented fitness experience to market. These descriptive codes mirrored topics in the interview guide. Public artifacts were coded similarly as they were titled, such as "user manual" and "privacy policy."

The second round of analysis featured more structured provisional coding. With provisional coding the researcher begins with a "start list" of codes based on what his or her prior "investigations suggest might appear in the data before they are analyzed." (Saldana 2012). These provisional codes arose from the interview guide and literature regarding the product development process. (Eppinger and Ulrich 2015)

Analysis in the third round featured in vivo coding to classify themes and concepts not captured in the first and second coding rounds. In vivo codes use the terms in the data itself. (Saldana 2012) For example, interviewees' expressed motivations for the product team to interact with users. When adding a new in vivo code, previously coded artifacts and transcripts were searched for similar occurrences and coded as necessary.

3.5 Case Creation

This section describes how each case was created through a multistep process of assembling interview excerpts and artifacts, writing the case text, sharing it with interviewees to ensure its accuracy, and revising the text. Note that at this stage of the method each case did not include my analyses identifying and assessing the impacts of explanatory factors on the data ecosystem design. That text was added after the activities described in the next section, Case Analysis.

Each case features a chronological account of the events that transpired when creating the instrumented fitness experience. This style was chosen because it lends itself to explanatory case studies, where potential causal and explanatory factors occur over time. (Yin 2013) This style was further chosen because the cases can stand alone as fact-based accounts of these development efforts, which are valuable to contemporary companies developing similar technologies and the research community. Following a similar structure also eases the case analysis process, which is described in the next section.

Initial draft cases were created by arranging coded data into a chronological timeline across three primary stages in the product development process: concept, development, and release. For example, transcript excerpts regarding the product team's initial ideas for the instrumented fitness experience were gathered together in the concept stage. Excerpts from public artifacts describing the released instrumented fitness experience, such as what data

it collected from users, were gathered into the release stage. The cases were not drafted in a historical sequence from the oldest to most recent, rather in a mixed sequence in order to better provide equal weight and attention to each section. (Yin 2013) These timelines were converted into narrative text. All interviewees were identified with pseudonyms to ensure privacy.

The draft cases were shared with interviewees to improve the accuracy of the events and decisions they depict. For each case, interviewees were provided via email an electronic copy of the draft case or a private link to a secure, Internet-accessible copy of the draft case. Interviewees were invited to assess the accuracy of the events and decisions depicted in the draft case, clarify any of their statements, and pose questions. Feedback was collected either on the case draft or via email. Interviewees' participation was optional, and comments were collected via pseudonyms to ensure privacy. Interviewee comments focused primarily on the sequence of events depicted, the decisions team members faced, and the options considered during those decisions. Draft case studies were updated with this feedback and again shared with interviewees for their input regarding the accuracy of the events and decisions depicted in the cases.

3.6 Case Analysis

Analysis with the focused comparison method is an iterative process. A collection of identical related questions and hypotheses are posed to multiple cases, with the goal of identifying similarities and differences amongst the cases. (George and Smoke 1974) This process of questioning and comparing repeats in order to reveal possible generalizations, the combination of factors that explain a phenomena's outcome. These generalizations can then serve as patterns to predict the outcome of similar phenomena.

Initial questions posed in this analysis focused on mapping the data ecosystem underlying the instrumented fitness experience in the case: what personal data is collected in the ecosystem and how, and what data and information is distributed, how, and to whom. Answering these questions confirmed the assertion in Chapter 1: Introduction that different product teams design their data ecosystems differently. With this foundation, analysis turned to identifying hypotheses explaining the variance in the ecosystem designs.

Findings from a prior exploratory study of companies' efforts developing instrumented experiences in the automotive, fitness, and entertainment domains served as the starting point for questions and potential hypotheses. That prior study found that companies creating instrumented experiences encountered challenges related to several areas. First, challenges addressing the technical complexities of collecting and analyzing data. Second, securing social license from the public for their instrumented experience. Third and related to the second area, understanding the impact of regulations on the instrumented experience. Each of the challenge areas led to questions that served as initial analysis points for this study.

Companies in the prior study encountered technical challenges creating instrumented experiences, and addressed those challenges in part through relying on other companies'

expertise. For example, a company in the prior study that did not consider itself expert with respect to collecting users' data adopted another company's technology to collect data. This finding led to posing a collection of questions to each case: did the product team encounter challenges designing their ecosystem? were those challenges of a technical and/or non-technical nature? for the non-technical, what explains why the team was challenged? what strategies did the product team use to address these challenges? how did those strategies impact the design of the data ecosystem? Evidence from the cases led to the following hypothesis for explaining teams' responses to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences:

Product teams design the data ecosystems for their instrumented fitness experiences based primarily on their interpretation of the relative importance of the team's expertise, the knowledge they have acquired through prior experiences.

Prior study companies cited challenges securing social license for their instrumented experiences. That is, interacting with the public to negotiate and earn approval for how their instrumented experiences collected, analyzed, and distributed users' personal data. In essence, the companies strove to understand the public and users' needs, and through fulfilling those needs secured social license for their instrumented experiences. This focus on understanding needs, particularly of those who would use the instrumented fitness experience, led to posing the following questions to each case: how did the product team interact with users? for what reasons did the product team interact with users? if not, why not? what did the product team learn from interacting with users? how did those learnings impact the product team's decisions regarding the data ecosystem design? Case evidence led to a second hypothesis:

Product teams design the data ecosystems for their instrumented fitness experiences based primarily on their interpretation of the relative importance of user needs.

Lastly related to the prior study, companies encountered challenges related to the legal aspects of collecting and distributing personal data. Companies were uncertain regarding what laws applied to their instrumented experiences and how those laws might impact the design of their technologies. This finding led to posing the following questions: how did the product team identify laws and regulations that might apply to the instrumented fitness experience and its data ecosystem design? how did the product team assess the applicability of those laws and regulations? in light of identifying relevant laws and regulations, what aspects of the data ecosystem design did the product team change? Evidence in the cases led to a third hypothesis:

Product teams design the data ecosystems for their instrumented fitness experiences based primarily on their interpretation of the relative importance of relevant regulations regarding the collection and use of personal data.

Posing these questions and assessing case evidence led to uncovering a fourth collection of candidate explanatory factors for the variance in teams' responses to their uncertainty. For example, one product team cited how fulfilling their desire to differentiate their instrumented fitness experience in the marketplace with a novel information-related feature impacted what data was collected in the ecosystem. This observation was posed as questions to the other cases: did the desire to differentiate the instrumented fitness experience impact the ecosystem design? if so, how? Other observations led to additional questions, including: did the product team price the instrumented fitness experience to spur adoption? if so, how did that pricing strategy impact the ecosystem design? did the product team interact with outside companies regarding creating complementary services for users? if so, did those interactions impact the design of the data ecosystem? These questions clustered around concepts from the information economics field, leading to a fourth hypothesis:

Product teams design the data ecosystems for their instrumented fitness experiences based primarily on their interpretation of the relative importance of information economics concepts.

3.7 Conclusion

The four hypotheses serve to disentangle the myriad factors explaining the variance in the cases' data ecosystem designs. As noted earlier, they are informed by findings from a prior study, however the hypotheses themselves were inductively generated through iteratively posing questions to and comparing evidence from the three study cases.

The dissertation continues with the study's three cases. Each case opens with a summary theory of the case identifying the principal factors shaping the product team's decisions regarding designing the data ecosystem of the instrumented fitness experience. The creation of the instrumented fitness experience is then presented across three stages. After each stage, conclusions are drawn regarding the factors shaping the product team's data ecosystem design decisions during that stage. Each case concludes with an assessment of the principal factors across the three stages. Additional conclusions, particularly those drawn from a focused comparison of the cases, are presented in Chapter 7: Identifying the Variance and Chapter 8: Explaining the Variance.

Chapter 4

Suunto T6, 2004

4.1 Introduction

Since the mid-1930s Finland-based Suunto has created handheld devices for individuals. From navigational compasses to wrist-worn dive computers, and mountaineering and fitness watches, Suunto's devices have helped fulfill users' needs while experiencing the outdoors. Suunto's T6 continued in that tradition.

Released in mid-2004, the T6 bundled a watch, wireless heart rate data collection sensor, and desktop software and web-based suuntosports.com for viewing collected data. The T6 analyzed users' heart rate variability and returned two new forms of information: EPOC (Excess Post-exercise Oxygen Consumption) and training effect. Users could import and export their data to and from the desktop software and suuntosports.com.

The product team's response to its uncertainty regarding designing the Suunto T6's data ecosystem, including what data it collected and how, and what data and information it distributed to whom and how, is principally explained by the team's interpretation of the relative importance of its own early adopter user needs. The team designed the ecosystem to collect data from multiple sources and to return new insightful fitness information to users. The latter feature differentiated the T6 in the market. The team's interpretation of the relative importance of its expertise and information economics concepts were minor determinants of its response. The team's interpretation of the relative importance of regulations do not appear to have impacted its response.

The Suunto T6 is significant because the product team's decisions led to an ecosystem design that featured the flow of data into the ecosystem from a range of sources, and the flow of data out of the ecosystem. The design reflects the product team's decisions to support early adopters' user needs: the ability collect data from multiple sources, import existing activity data, download their collected activity data, and return new information to improve users' fitness.

This case presents a history of the T6 across three stages. During the concept stage the product team identified a potential business opportunity for what would become the

T6. The product team engineered and tested the T6 in the development stage, and made it available to consumers in the release stage.

The case details and analyzes the product team's key decisions during the concept and development stages. It assesses how those decisions impacted the design of the T6's data ecosystem during those stages, and how the outcome of those decisions manifest and were communicated to users in the released data ecosystem. Figure ?? on page ?? depicts the publicly released data ecosystem design.

The case draws on two data sources. First, interviews with four key T6 product team leaders and members with responsibilities across all three stages. Interviewees include the T6 product manager, T6 project manager, lead software engineer, and Head of Consumer Software Development. Second, publicly available artifacts distributed and/or created by Suunto, including T6 product documentation and marketing materials. Artifacts were collected in print and as well as from online via the company's web site and the Internet Archive's Wayback Machine, which stores archived copies of public web pages and web-accessible media.

4.2 Concept Stage

The idea for what would become the Suunto T6 arose from the company's experiences developing and releasing its earlier watches for the performance sports fitness device market: the Advizor, X6, and X6HR.¹ Released in 2002-03, these watches collected users' personal sports activity data, such as altitude and lap times, and for the Advizor and X6HR, heart rate. Users could interact with their collected data on the watch itself, and for X6 and X6HR users via the desktop computer-based Suunto Activity Manager software. X6 and X6HR users could also view and share collected data with other users and the public on suuntosports.com. The watches ranged in price: \$330 for the Advizor, \$360 for the X6, and \$450 for the X6HR. See Table ?? for a summary of the watches' features.

Suunto's Advizor, X6, and X6HR entered an emerging yet competitive performance sports fitness device market. The company's competitors approached the market with different solutions. Polar Electro focused on heart rate monitoring, which it pioneered in the late 1970s.² Garmin leveraged its global positioning system (GPS) technology to introduce its wrist-wearable GPS-based location and distance tracker, the Forerunner 201, in 2003.³ Timex's Bodylink watch of 2003 featured both heart rate and GPS-based location.⁴ Each of these competing offerings provided a means for users to interact with their collected data on the device itself and via desktop software bundled with the watches, but not online. With

¹Suunto Devices. <https://web.archive.org/web/20030402060227/http://www.suunto.com/pls/suunto/suunto2.pubmainpage.frameset>

²Polar Global. Polar Origins. http://www.polar.com/en/about_polar/who_we_are/polar_origins

³Garmin Corporation. Garmin Unveils GPS-Enabled Forerunner 201 Personal Training System. August 14, 2003. <http://www8.garmin.com/pressroom/outdoor/081403.html>

⁴Timex. Bodylink Devices. <http://web.archive.org/web/20030814012831/http://www.timex.com/bodylink/devices.html>

Table 4.1: Suunto Devices

	Advizor	X6	X6HR
Data Collected & Distributed	altitude barometric pressure compass direction lap time ascent rate descent rate heart rate	altitude barometric pressure compass direction lap time ascent rate descent rate	altitude barometric pressure compass direction lap time ascent rate descent rate heart rate
Data Distributed via	watch	watch desktop software desktop software	watch suuntosports.com suuntosports.com
Data Distributed to	Advizor user	X6 user suuntosports.com users public non-users	X6HR user suuntosports.com users public non-users

the development of the Advizor, X6, and X6HR, Suunto would strive to further differentiate its future offerings with new and unique features and functionality.

Suunto's decision to create the Advizor, X6, and X6HR arose from its interactions with users regarding desired features and functionality with the company's existing diving and outdoor watches. The company strove to appeal to these users by offering durable watches for rigorous outdoor use. The product team characterized the company's users as early adopting technology enthusiasts interested in logging data about their activities, analyzing that data, and using the results of that analysis to understand themselves and their activities.

Suunto's users provided feedback regarding the watches by reaching out to the company's customer support department via email, telephone, and by posting comments on online forums. The product team collected and reviewed these requests, and added them to their own ideas.

Much of the product team was composed of similar early adopting outdoors enthusiast divers, runners, cyclists, and climbers with their own needs and ideas. Team members used the company's devices as part of their outdoor activities. Users and product team members desired two key features for the company's future watches: heart rate-related data and the ability to view, interact with, and share their data online and via their computer.

Users desired heart rate-related data, such as their heart rate and heart rate zone, for their activities. Users believed heart rate data would provide insight into their exertion effort while exercising, such as indicating when they were over-exerting themselves and risking injury. Such data could be collected by a sensor and transferred wirelessly from the sensor to the watch. Suunto addressed this user need with its Advizor and X6HR watches.

Users also desired the ability to view their data on a computer and online, as well as the ability to share their data with others. Users inside and outside the company cited creating

paper-based logbooks to record training activities, including where and when they trained and for how long, as well as how they felt afterwards. Users shared these logbooks with coaches and friends for analysis and feedback.

The product team responded to this need in part by developing the Suunto Activity Manager desktop software, where users could use their desktop computer to view and interact with data collected by the X6 or X6HR. The lower-priced Advizor did not feature the ability to view collected data via Suunto Activity Manager. The team turned to an outside company's technology to fulfill the request to view and share data online.

In early 2000 Helsinki startup Meiga Innovations approached Suunto's parent company, Amer Sports, with an Internet-based service where users could upload, view, and share their fitness activity-related data. As described by the founder of Meiga Innovations:

Our mission at those times was to connect all sports loving people, athletes, sports athletes who want to probably share the experiences while doing sports, and it obviously didn't exist at those times. – Suunto Head of Consumer Software Development

Suunto identified this Internet-based service as an opportunity to fulfill users' request to view and share data online as a new form of electronic logbook. Suunto acquired Meiga Innovations in April 2002,⁵ renamed the company internally as Suunto Software Solutions, and renamed the service Suunto Sports.

When (Suunto Software Solutions) offered this to us, then we decided okay, this is an interesting angle and a unique thing on the market. We thought that this could be an opportunity for us to enter this performance sports market with something that is competitive and takes things forward. – Suunto T6 Product Manager

Suunto entered the performance sports fitness device market in mid-2002 with the release of the X6, Advizor, and X6HR watches. The company offered three watches at varying price points, from \$330 to \$450 to appeal to different user groups based on features and functionality.

As with its earlier devices, the product team fielded feedback from users regarding the watches' features and functionality. These external users contacted the company's customer service department via email, telephone, and through posting comments on online forums. As noted earlier, these users were early adopting technology enthusiasts.

The product team paired this public-sourced feedback with team members' own experiences and ideas to determine the features and functionality of its next generation device, which would be known as the T6. The majority of product team members were, like users outside the company, early adopters of fitness technology and experienced athletes.

⁵Amer Group PLC. Amer Group Becomes Majority Shareholder of Meiga Innovations, a Sports Software Specialist. April 16, 2002. <http://www.investegate.co.uk/ArticlePrint.aspx?id=200204160840185836U>

External users expressed an interest in GPS-based distance tracking. GPS development costs were perceived as significant and outside the company's core competencies. As demonstrated by competitor Garmin's Forerunner 201, displaying GPS-based location on a mobile device required considerable power, resulting in a short battery life. Interacting with mapping data on such a device was cumbersome for users and few means existed to interact with map data via a computer or web site.⁶ The product team opted against including the GPS-based distance tracking in its next device, instead looking to competitors' offerings for alternative ways to gather distance data such as through a sensor worn on the user's shoe or bicycle.

Product team and external users also expressed interest in additional heart rate-related information, beyond existing heart rate beats per minute. Based on their experiences, the team believed that such information did not provide experienced users like themselves with actionable insights to improve their fitness.

Just having heart rate limits or zones doesn't really tell you what you gain. –
Product Manager

The team decided that the T6 would need to return actionable information to differentiate itself from competitors' offerings. The team was uncertain what the actionable information could be, and did not have the knowledge to create it itself. The product team was inexperienced with analyzing and converting data into new forms of information.

At the same time in 2002 university researchers at the Finnish KIHU - Research Institute for Olympic Sports identified a new means to measure fitness performance and improvement. The researchers found that measuring heart rate variability, the time between heart beats, provided a more accurate assessment of an individual's fitness and performance than simply comparing beats per minute, which was common in the consumer fitness market at the time. The researchers' analysis returned two novel forms of information: EPOC (Excess Post-exercise Oxygen Consumption) and training effect. These two new forms of information provided users with insights about the impact of their exercise activities on their overall fitness.

EPOC measures how hard a training session was on the user's body, and training effect indicates when a training session has improved the user's condition.⁷ With this information users could moderate their future exercise activity levels to maintain or improve their fitness. The researchers formed their own company, FirstBeat Technologies, to introduce EPOC and training effect to the consumer fitness market.

In 2003 FirstBeat approached Suunto with its analysis. The Suunto product team identified that FirstBeat's EPOC and training effect would fulfill users' needs for actionable

⁶At this point in early 2004, MapQuest and Yahoo were amongst the few providers of Internet-based consumer mapping services. Google Maps and Open Street Maps would launch in February 2005 and August 2006, respectively.

⁷FirstBeat Technologies. A Personal Training Tool To Optimize Training Results. <https://www.firstbeat.com/fi/uutiset/lehdistotiedote-uusi-suunto-t6-markkinoilla-in-english/>

information, as well as differentiate its proposed T6. No other competitive offerings featured EPOC, training effect, or similar information. The companies formed a partnership, where Suunto would license this analysis from FirstBeat and integrate it into its next generation watches.

The product team turned to determining how it would collect needed data from users. The watch would need multiple sensors to collect users' data: a heart rate monitor and distance sensors. This need for supporting multiple sensors arose from runners and cyclists on the product team and outside the company interested in tracking their heart rate and distance while exercising.

The team faced the decision of how to develop these sensors. Based on its' experience developing the heart rate sensor for the earlier X6HR watch, the team decided that its engineers would design a new sensor that could collect the needed heart rate variability data.

The product team recognized that it was less experienced designing the two needed distance sensors: a shoe-worn cadence sensor measuring a runner-user's steps and a sensor measuring a cyclist-user's wheel rotations. Data from both sensors would then be analyzed and converted into distance run and ridden, respectively.

The product team explored ways to wirelessly transfer collected fitness and activity data from these multiple sensors to the user's watch. The team was experienced developing wireless transfer technologies from its efforts creating the earlier heart rate-focused Advizor and X6HR watches. The technology only worked with a single sensor, the chest-worn heart rate monitor, and users on the product team and outside the company found that data transfer was erratic.

The typical way was, for instance, to transmit heart rate from a chest belt to a watch was an inductive transmission based on magnetic induction. There, the range is up to like three feet, one meter. Then that's basically for yourself only. From the chest to your wrist. – Product Manager

The company's existing wireless sensor collection technology could not collect data from both a heart rate monitor and cadence sensor, which would be of interest for a runner or cyclist user. The technology was power-intensive, requiring the user to frequently replace small, expensive batteries. The proposed watch featuring multiple sensors would need a new and more reliable wireless transfer technology, as well as a chip to process the collected data. The team faced the decision of using its experience to create that technology or turning to another company for assistance.

The team recognized that it was inexperienced with developing such technologies. The product team turned to two outside companies, Dynastream Innovations of Canada and Nordic Semiconductor of Norway, for assistance. Per the Product Manager:

We knew there will be wireless radio chips (from Nordic Semiconductor) available that are operating at low enough power level that can be used to build into a small

sensor device in the watch. We started working on a protocol (with Dynastream Innovations) that would enable connecting several different devices together, and then we saw that this would open a lot of interesting opportunities in sports monitoring market, including group monitoring, simultaneous group monitoring, or a personal sensor network that you could carry at the same time, three, four, five different sensors, like by speed, cadence, power, heart rate and so on. – Product Manager

The combination of the ability to collect data from multiple sensors and then analyze that data to return actionable information to users revealed the opportunity to fulfill two key users needs, leading to what would become the Suunto T6.

We had these two technological elements in place, and we thought that this could be (the) foundation of a very interesting product. – Product Manager

Concept Stage Summary

The product team's interpretation of the relative importance of early adopter users needs was the key determinant shaping the team's response to its uncertainty regarding designing the T6's data ecosystem. The team's design decisions were further influenced by its interpretations of the relative importance of its expertise fulfilling those user needs and the information economics concept of differentiation. Evidence does not support that product team's interpretation of the relative importance of regulations influenced their response.

The Suunto product team gathered user needs primarily from team members and to a lesser degree similar users outside the company. Both user communities were experienced athletes and early technology adopters. Users sought the ability to collect multiple types of fitness data. The product team assessed that it was expert developing sensors needed to collect fitness-related heart rate data, but not distance-related sensors or the required multi-sensor wireless data transfer technology. In order to fulfill user needs, the team turned to Dynastream for the cadence sensor and transfer technology and Nordic Semiconductor for the watch's semiconductor chip. The team's decisions would impact what and how data entered the T6 data ecosystem, and what data it would distribute to users. The ecosystem would collect and distribute fitness data, and that data would be collected in part through an outside company's technology.

Users desired new insights from their collected data that could help them improve their performance and fitness. The team assessed that it was not expert creating these new insights, so it licensed EPOC and training effect from FirstBeat. The two new forms of information would differentiate the T6 in the marketplace. The team's decision would impact what data and information the data ecosystem would distribute to users: EPOC and training effect. As the sole provider of this information, FirstBeat would be an essential part of the data ecosystem.

In summary, at this stage in the T6's development case evidence supports that the product team's interpretation of the relative importance of user needs was the key determinant of its response to its uncertainty regarding designing the data ecosystem. The team's decision to fulfill user needs led to the team's interpretation of the relative importance of its own expertise and information economics concepts as determinants of the concept stage data ecosystem design. The team's interpretation of the relative importance of regulations do not appear to have impacted their response.

4.3 Development Stage

Suunto's development of the T6 began in 2003, with efforts distributed amongst three teams: the device team, desktop software team, and the suuntosports.com team. Development was led by the 10-member device team, which included the product manager, industrial designer, mechanical designer, and several hardware and firmware designers. The team developing the desktop software, renamed Suunto Training Manager, included a project manager and four software developers. The suuntosports.com team included twenty-five developers, which was the largest development team in the research and development department at the company at the time. Teams were distributed amongst buildings at Suunto's headquarters outside Helsinki, Finland.

The T6 team's first task focused on determining the device's detailed feature set, beyond supporting the user needs identified earlier in the concept stage. The team identified the target T6 user as similar to its existing products' target user: early technology adopting outdoor enthusiasts interested in logging data about their activities, analyzing that data, and using the results of that analysis to understand themselves and their activities. These initial user needs came from within the team. As noted by the product manager, the company at first did not interact with users either publicly or privately about their needs out of concerns that competitors would learn about the product.

We developed it quite far before really getting into this user involvement mode. Because it was a new area for the company. I mean a new market entry. We wanted to keep that quite secret until we are ready to launch. That's probably the overall concept where everything was kept quite quiet inside the company until we had really working samples. – Product Manager

Instead, during the early stage of development team members who closely resembled potential T6 users stood in as proxy users.

Our project manager, he was an athlete. He did test the devices in the very early stages and he gave us immediate feedback. Internally, yes, but not with external users – Lead Software Engineer

These internal team member users' needs guided key decisions about the T6 feature set. As noted earlier, one user need focused on providing users with actionable information to improve their fitness. Fulfilling that need would require data from users. The device team identified that such data and information related to three areas.

We already had some data that we were measuring in our other devices in the outdoor use about the environment. That was our signature area. We wanted to keep that. Then there was this new physiological side that became possible through (Firstbeat's) heart rate analysis. Then we certainly wanted to include this performance parameters like speed and distance and things that are more about your output and results. It was a combination of three things: your body, your sports performance, and the environment. – Product Manager

Collecting, analyzing, and displaying environmental data such as altitude, barometric pressure, and temperature was a hallmark of Suunto's prior devices. The team believed existing Suunto users would expect this data, and it would differentiate the product amongst competitors. The team would leverage its prior experience and knowledge developing sensors for collecting altitude, barometric pressure, and temperature data.

The team further identified what body and sports performance data would need to be collected from users. Firstbeat's analysis algorithms would need data from users in order to calculate EPOC and training effect. This data included age, gender, weight, height, smoking status (yes/no), and prior activity class on a scale (0 = no sports to 7 = active sports). The team decided that this data would be collected from users when they created their suuntosports.com account. The team built on its prior experience developing the heart rate sensor for the X6HR to design a heart rate sensor that collected heart rate variability, as required for Firstbeat's analysis.

Suunto, Dynastream, and Nordic Semiconductor collaborated regarding the technologies that would collect, transfer, and analyze users' data. Nordic Semiconductor would provide its nRF2401A chip for the T6 watch. The chip would analyze users' collected data, such as their altitude and heart rate, for display on the watch. Suunto and Dynastream would supply the heart rate and distance sensors, respectively.

During development the Suunto team found size and accuracy shortcomings with the supplied sensors. The team pushed Dynastream to develop a new sensor for the T6.

Dynastream had also developed this foot pod technology which was acceleration sensor-based speed and distance for running. Then they already had two products using that technology on the market. One was with Nike and another with Polar. We worked with them to develop a new one which is much smaller and actually became more accurate through how we processed the data. – Product Manager

The team also collaborated with Dynastream to develop a new means to wirelessly transfer collected data from multiple sensors to the watch. Dynastream directed much of this effort given its expertise developing such technologies.

We were also cooperating with the Canadian company Dynastream that was later acquired by Garmin. We hired them to develop the wireless protocol for the 2.4 gigahertz radio communication. Development was initiated by us. Then we started using the first version of it, which was just for the Suunto network of devices. – Product Manager

The team envisioned the protocol as a potential standard for the industry. The idea of developing a standard arose from the team as a counter to efforts by Suunto competitor Polar Electro, who utilized a closed, proprietary standard for transferring data between its sensors and devices. For example, a Polar Electro sensor could not be used with a Suunto, Garmin, or competing device.

It was our speculation at the time that Polar, they didn't want to do these kind of things. It was very closed, because everybody thought that that's the key to good business ... to develop a central, closed system. Polar management would not give it out to other device manufacturers. – Head of Consumer Software Development

The product team saw their approach as creating a new platform for the emerging fitness device market, one that would benefit the company, users, and fellow competitors. Ideally that protocol would become a standard for collecting and transmitting data in the expanding digital fitness marketplace.

Our idea actually was to develop a standard for data collected with different type of sensors in sports instruments. Everyone benefits who is in the same platform. – Head of Consumer Software Development

In February 2004, Suunto and Dynastream announced their partnership to collaboratively develop and bring this new wireless data collection standard to market with Suunto's next watch.⁸

Alongside determining the T6's data needs and developing ways to fulfill those needs, the T6 team also worked on designing the watch itself and updating the existing Suunto Training Manager desktop software and suuntosports.com. The team decided to extend the earlier X6 and X6HR physical design for the T6, using many of the same internal components.

The team updated the desktop software and web site to include Firstbeat's analysis. The companies implemented a figurative black box arrangement, where Firstbeat's analysis algorithms would process raw user data provided by Suunto and return EPOC and training effect. Suunto would not have visibility into how EPOC and training effect were calculated. Firstbeat's algorithms would be embedded within the desktop software and web site to analyze users' data. With such an arrangement users' collected data would not be shared

⁸Dynastream Innovations. Announces New Design Partner and Customer Suunto. February 9, 2004. <http://web.archive.org/web/20040608142536/http://www.dynastream.com/news/view/20/>

with Firstbeat. Suunto would have sole access and control over the data. The team also updated the desktop software to accommodate users' desires to import their existing fitness data to the desktop software and web site for analysis, and the ability to export all of their collected data for their own analysis. Users could then analyze their downloaded data with available spreadsheet software.

The team's development efforts also focused on fulfilling user needs for a means to analyze and share their data with other users. As noted earlier, the product team and those outside the company in the target T6 user group created paper-based logbooks to record their training activities, which they would then share with one another and coaches for analysis and feedback. Rather than turning to another company to develop such an interactive online logbook, the team decided to re-envision its' existing suuntosports.com site as an online version of such a logbook.

The online log book would allow users to track their activity and progress over time, and share that information with other users. As the first mover in the space, the suuntosports.com team could not look to competitive offerings to help guide their efforts.

When it comes to integrating data and collecting the data and sharing data and the experience, we were quite sure that we were – I mean it was the only platform, existing platform when we published it. I didn't come across similar sites at those times. – Head of Consumer Software Development

The team envisioned that after exercising users would sync their T6 device to their desktop via Suunto Training Manager, then have the option of uploading it to suuntosports.com. The site would leverage the data provided by the device and the user's earlier-described basic personal parameters, but would need additional data from users in order to support the team's vision.

It was all about sensors and what we could measure. However, we wanted to add the storytelling layer, and also integrated different types of data to understand what actually happened during an exercise activity. – Head of Consumer Software Development

These additional data points would include first name, last name, address, postal code, city, country, state, favorite sports, and language. Users would be able to annotate their uploaded exercise activities with text-based descriptions, just as they did with their paper-based training log books. These annotations would contribute to the referenced storytelling layer.

The Head of Consumer Software Development noted that the team did not plan to use all of the data they collected from users during the registration process, as analyzing that additional data was not their objective.

It was those times when people like us thought that they have to ask everything about users. Our objective was really never to analyze anybody's personal data

or even collections of the data, but to let people to talk about them. – Head of Consumer Software Development

During the development stage the T6 team recognized it would need to comply with regulations regarding how it collected and analyzed users' personal data, and that those regulations might be specific to each market for the T6's planned global release. The T6 might need to comply with regulations in the European Union, United States, and other regions. The team turned to Suunto's lawyers for guidance, who directed the team to comply with Finnish Personal Data Act 523/1999.⁹

We had to cope with the regulations for this kind of a consumer database (suuntosports.com). There was no approval needed for that, just laws and regulations for how things had to be done. – Product Manager

The team perceived Finnish regulations as the most specific and stringent amongst regulations in European Union and United States. By complying with these regulations the T6 would also comply with less-stringent regulations throughout the world. The team would then be able to develop and provide a consistent user experience throughout the T6's intended global market.

Per regulations, the T6, desktop software, and suuntosports.com could only collect data from users with their explicit permission and that data could only relate to their experience using the T6. The team decided to clearly describe what data the T6 collected in all user-facing documentation. Per regulations collected data could not be shared with any other companies without users' explicit consent. The team decided to communicate that it would never share data with other companies, and as noted earlier, designed its data analysis arrangement such that Firstbeat never had access to users' data.

The team could fulfill this requirement by providing users with a means to request their data online or offline and then processing the request, or by allowing users to download their data at any time without Suunto's assistance. The team opted for the latter, citing the earlier-referenced user need to download their data.

During development the team explored the possibility of pursuing medical device compliance in the European Union.¹⁰ The team had considered such compliance during the earlier concept stage.

We studied the possibility to get it listed – especially to get the heart rate belt approved by medical authorities, but then we found out the way we had it manufactured didn't really enable us – there was no readiness for that kind of approval, so we didn't pursue that one. – Product Manager

The costs of seeking regulatory compliance were prohibitive:

⁹<https://www.finlex.fi/en/laki/kaannokset/1999/en19990523.pdf>

¹⁰Council Directive 93/42/EEC of 14 June 1993 concerning medical devices; <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:01993L0042-20071011>

We wanted to be on the entertainment side. It's purely because all that regulatory work would have been a massive cost to us. – Head of Consumer Software Development

In light of these discoveries, the team decided to position the T6 as more sports-related than medical or health-related. Such positioning would ease the need to comply with more stringent regulations than the earlier-cited Finnish Personal Data Act 523/1999.

We didn't claim it to be a medical device or health data. It was just sports data, so there was no requirement in that sense. – Product Manager

In spring 2004 the team had a working T6 system that could collect data, transfer data to a desktop computer and suuntosports.com, and return Firstbeat's EPOC and training effect information. The team began interacting with a broader set of product team and company users, and recruited users outside the company to interact with and evaluate the T6.

We had a basic network all over the world. When we had the testing first going we asked the sales people, the local retailers or the trusted partners to recruit some users for us. We had a few ambassador athletes, mainly in Finland. – Head of Consumer Software Development

These external testers came from a variety of exercise and activity pursuits, and joined the internal testers on the product team and inside the company.

All were testing it under NDA (non-disclosure agreements). We had quite many active users in the company, some runners, trail runners, and others. – Product Manager

The T6 team tasked users inside and outside the company with specific activities:

We had an explicit training plan to send them. We wanted them to understand what is training effect. We wanted them to understand how to transfer the data into your computer and follow graphically your performance, and then how to share the data on the Internet. – Head of Consumer Software Development

Interacting with these users was a hands-on experience, requiring the team to spend significant time and resources with users to ensure they understood how the system worked. The team found that these users were no longer primarily early adopting lead users such as themselves.

It wasn't just that you sent them by mail, the instruments and the software application. Then okay, let's be back in one month's time. We actually had to teach them how to use this. This was one of the key challenges that we faced all the

time, is that some of the feature were so advanced that the user couldn't – they didn't know what to do or how to do things. It's expensive to teach new technology to users that are not techy. – Head of Consumer Software Development

The team quickly identified that the complexity of the T6 system posed user experience challenges.

It was a couple of things that the overall usability of the system, because it included quite many components. It had the watch and then the external sensors. Then it had PC software and a cable to connect your device to your computer, and then there was a web site where you could post your activities. It was a large system, and more different bits and pieces of anything that we had before. Getting it working and getting it set up is enough. It was probably the most important thing. – Product Manager

Since the team had not reached out to a broad range of external users early in the development processes, the team did not have the time to incorporate their feedback to improve the T6's usability. The team would use their feedback to inform the design of future watches.

The T6 team also reached out to professional coaches for feedback on the T6 and web site, as well as to gather endorsements and marketing ideas. The team was also interested in the coaches' response to the Firstbeat measurements. Since the team had not reached out to a broad range of external users earlier in the development processes, the team did not have the time to incorporate their feedback to improve the T6's usability.

By late spring 2004 the product team determined the T6 was ready for release.

Development Stage Summary

During the development stage the product team's interpretation of the relative importance of early adopter user needs continued to be the key determinant of the team's response to its uncertainty regarding T6's data ecosystem design. The team's interpretation of the relative importance of its expertise fulfilling those user needs and the information economics concept of differentiation were minor determinants. Its interpretation of the relative importance of regulations do not appear to have been a determinant in the data ecosystem design during the development stage.

Users sought the ability to collect and view environmental data, such as altitude and compass direction. The product team assessed it was expert developing the needed environmental sensors based on its prior experiences. Suunto's users needed the ability to import their existing training activity data, as well as access to their data for their own analysis and for sharing with friends and coaches. The team's decisions to support these needs impacted what data entered the ecosystem and how, as well as what data and information was distributed by the ecosystem and to whom. Users would be able to import their training

data from competing systems, as well as export their data to switch to a competing system. Supporting this user need would lower users' switching costs, both to adopt the T6 or switch to a competing device that allows users to import their data.

The product team turned to Dynastream and Nordic Semiconductor for assistance fulfilling users' needs for which the team perceived it lacked expertise. Dynastream and Nordic Semiconductor's technologies became part of the ecosystem, however the companies did not have access to the data their respective technologies collected, transferred, or analyzed in the ecosystem.

Again due to lack of expertise, the product team turned to Firstbeat for assistance fulfilling users' need for new, insightful information that would also support the team's interest in differentiating the product in the market. The decision posed a key data ecosystem design question: how and where users' data would be analyzed to create that information. Regulations stipulated that Suunto could share users' data with FirstBeat for analysis, however it must inform users of this sharing. The team decided that it would not share users' data with third parties. While it is unknown why the team made this decision, it is reasonable to believe early adopter users such as themselves opposed such sharing. The team embedded Firstbeat's analysis algorithms within the T6's desktop software and suuntosports.com. In so doing Firstbeat became part of the ecosystem, but did not have access to users' data in the ecosystem.

The product team's interpretation of the relative importance of regulations do not appear to have been a determinant of its response. The product team found that regulations stipulated that the company must fulfill users' requests for their collected data, but did not specify how those requests be fulfilled. The team could have chosen to require users to submit their request in writing. Doing so would have raised users' switching costs to move to a competing product. Instead the team opted to support early adopter users' need to export their data at any time, which complied with the regulations. That decision reduced users' switching costs, making it easier for them to take their data to a competing product.

Summarizing the development stage, case evidence supports that the product team's interpretation of the relative importance of user needs, particularly early adopters on the team itself, continued from the concept stage to be the key determinant of the team's response. Also continuing from the concept stage, the team's interpretations of the relative importance of its expertise and information economics concepts were minor determinants. The team's interpretation of the relative importance of regulations do not appear to have been a determinant of its response.

4.4 Release Stage

Suunto announced and released the T6 in July 2004. The retail packaged T6 included the watch, a transmitter belt for collecting heart rate data, a USB-based PC-interface cable, CD-ROM containing the Suunto Training Manager desktop software, User's Manual, and

Training Guidebook, and print copies of the User's Manual and Warranty, Care, and Maintenance booklets. Users were directed to suuntosports.com via these print materials.

The T6 retailed for \$449.99 and was available through Suunto's web site and major retailers across the world. The optional shoe pod and bicycle cadence sensors were available in late 2004 for an additional \$109.00 and \$69.99, respectively. The competing Timex Bodylink 59551 and Garmin Forerunner 201 retailed for \$300 and \$160, respectively.^{11,12}

The product launch press release provides an overview of the T6's features and functionality. First, the release details what data is collected from users:

Suunto T6 combines a wristop unit and heart rate belt with PC software. Unlike conventional heart rate monitors that only measure the heart rate, the Suunto T6 measures the time interval between heartbeats and variations in it.

The release describes where that data is analyzed, the information that is returned to users from that analysis, and the value of that information:

From this precise data the Suunto T6 PC software calculates seven different body parameters and shows athletes, in a simple and easy way, how their physical condition is developing.

The returned body parameter information is further detailed, including the meaning and value of the new-to-the market EPOC and training effect information:

The seven body parameters that Suunto t6 measures from every training session are EPOC (Excess Post-exercise Oxygen Consumption), training effect, heart rate, oxygen consumption, energy consumption, ventilation and respiratory rate.*

EPOC is the absolute numeric value of oxygen that the body needs after training. EPOC is also a measure of how hard a training session was on one's body. When related to one's physical condition, EPOC tells whether the training session has improved one's condition or not. Knowing the exercise load and training effect helps athletes on every level to make an optimal training plan and to avoid both over and under training.

While the release does not detail how that new information is analyzed, it notes that the analysis is grounded in scientific research:

Suunto t6 utilizes the results of physiological research conducted by the Finnish KIHU - Research Institute for Olympic Sports, in cooperation with Firstbeat Technologies Inc. This scientific data enables Suunto t6 to offer users information

¹¹Timex Bodylink. <https://web.archive.org/web/20040404042720/http://www.timex.com/bin/detail.tmx?item=048148595514>

¹²Garmin International Inc.,. Garmin Unveils GPS-Enabled Forerunner 201 Personal Training System. 2003. <http://www8.garmin.com/pressroom/outdoor/081403.html>

from every training session that were previously measurable only in laboratory tests.

Specific functions are listed for the watch, software, and web site:

The main functions of Suunto t6 include heart rate monitor with a memory of over 100,000 heartbeats, watch, stopwatch, timer, altimeter and barometer.

The Training Manager PC software includes versatile analysis tools, logbook and calendar for training planning. It also allows the exchange of training information over e-mail and on www.suuntosports.com, enabling remote coaching and the sharing of experiences between athletic colleagues and friends.

The T6's product documentation provided users with further details of its features and functionality, including what personal data the T6 system collects, how that data is used, analyzed, and converted into information, and how users may share their collected data with others.

The T6 User's Manual describes the value offering for users:

For the first time in field conditions, Suunto t6 tells you whether your training really improves your condition and helps you adjust your training programs accordingly. When you set the target effect for your training, you can use the software to calculate the time and heart rate to reach it.

During a training session, Suunto t6 helps you reach the target by offering several control functions, such as heart rate limits, real time average heart rate, and a customizable display of stopwatch, lap time, interval timer and altitude. Together with versatile timing, altimeter and logbook functions this makes Suunto t6 a perfect performance monitor for all kinds of sports at all performance levels.

The User's Manual describes the personal data the T6 collects from users. First, users' heart rate data is collected by the chest heart rate belt. Second, the manual notes that a user's EPOC value is calculated based on their "height, weight, age, sex, smoking (yes/no), and activity level depicting the amount of prior exercise" (based on a scale of 0 to 7). These values are collected from the user when setting up the Training Manager software. The Training Guide further defines activity level:

Activity level means the amount of earlier exercising activity on a scale of 0 to 7. Level 0 means a person who never exercises, while 7 means a person who trains actively.

The desktop software also asks the user to entering their maximum heart rate, which is used to calculate their personal heart rate zones. The Training Guidebook notes that users may also contribute their maximum performance level and vital capacity (lung volume),

with those values being used to improve analysis accuracy. In the absence of users entering values for maximum heart rate, maximum performance level, and vital capacity, the Training Guidebook notes that these values are determined instead with mathematical formulas.

Additional user data is collected when users create their suuntosports.com account. The registration page requires that they enter their first name, last name, email address, city, country, language, year of birth, and gender. Users are also required to select a username. Users may optionally share their address, postal code, state, and favorite sport with the company.

The User's Manual describes the results of team's collaboration with Dynastream to implement a new protocol for wirelessly transferring data between the heart rate monitor and other sensors and the watch. Dynastream is not named in the User's Manual or Training Guidebook, nor is Nordic Semiconductor.

The User's Manual describes how the new method is an improvement over existing methods, and the incompatibility of existing sensors.

Suunto t6 can be upgraded with different wireless accessories, such as speed and distance sensors. These ANT accessories and the Suunto t6 heart rate belt communicate digitally on 2.4 GHz radio frequency. This offers several benefits, such as improved transmission capacity, error-free 2-way transmission and range up to 10 m / 33 ft. Conventional heart rate monitoring devices use inductive low frequency communication methods. Therefore other heart rate belts are not compatible with Suunto t6.

The T6 User's Manual and Training Guide detail what information is provided to users as a result of analyzing their data. This returned information is not presented in an exhaustive list, rather distributed throughout these documents. This information includes the press release-referenced seven body parameters (EPOC, training effect, heart rate, oxygen consumption, energy consumption (calories), ventilation and respiratory rate), as well as heart rate zones, altitude, barometric pressure, ascent rate, descent rate, cumulative ascent/descent, temperature, and VO₂max (aerobic capacity). The optional shoe pod and bicycle cadence sensors released later in 2004 returned speed and distance. The Training Guidebook, sub-titled How Not to Rely on Luck When Optimizing Your Training Effect, provides users with extensive detail regarding how to use EPOC and training effect to guide their training activities.

Suunto's Training Manager software allowed users to import and export their data. Users could send imported data to suuntosports.com, where it could be then shared with other users and the public. All collected data was available for export, and could be shared with other people via email. Data was made available in Suunto's own comma-separated value-based SDF format, which could be read with common data analysis software.

The T6 materials do not address whether the information returned to users is medical information, or whether the T6 may be construed as a medical device. The User's Manual and Training Guide book advise, respectively:

Exercise may include some risk, especially for those who have been sedentary. We strongly advise consulting your doctor prior to beginning a regular exercise program.

Before you begin a training program, you may want to consult your physician.

The User's Manual provides users with general information about how their data is analyzed, but does not reference that the analysis is based on research from the Finnish KIHU - Research Institute for Olympic Sports, as disclosed in the press release. The User's Manual discloses:

The heart rate analysis of the software is based on the calculation model developed by Firstbeat Technologies Ltd.

The Training Guidebook provides users with additional information about how their data is analyzed, the accuracy of that analysis, and how to improve that accuracy. First, it notes that analysis is dependent on the user, with the more accurate the personal data provided the more accurate the analysis.

The accuracy of Suunto Training Manager's performance analysis is largely dependent on the correctness of the background information you have specified.

This background information is similar to that collected from users when creating their suuntosports.com account, as well as smoking status and activity level depicting the amount of prior exercise. The Training Guidebook notes that the accuracy of the T6 system's analysis improves if the user enters their known maximum heart rate and performance heart rate, which the user can acquire via a laboratory-based performance test. The User's Manual notes accuracy is further improved when users enter their resting heart rate. Both the Training Guidebook and User's Manual remind users to update such background data whenever they change in order to receive accurate analysis results.

The suuntosports.com Registration Page provides users with control over what information about them is shared with others site users. Users may opt-into their profile's name, gender, and age being shown to others users. Users may also opt-into their email address being shown to other users. Users may opt-into receiving e-mail marketing messages about Suunto and its products.

Within suuntosports.com users are provided control over whom may view their activity data:

You can decide whether you want to make your logs and/or training programs public to all members, to limited groups or to keep them just for your own use.

These limited groups are smaller communities of suuntosports.com users, such as friends with similar interests.

Users are informed that other users' shared activities are valuable for comparison:

In My Suunto, you can also compare your logs and/or training programs with the ones that others have published.

The suuntosports.com Terms of Membership / Registration Agreement details that information collected from users on suuntosports.com will be handled per Finland's privacy protection legislation.¹³

The suuntosports.com Terms of Membership / Registration Agreement further note that the company:

will not transfer collected visitors' information to any third party

Release Stage Summary

Much of the design of the T6's data ecosystem is revealed in the T6's public artifacts, as they convey what and how data is collected, as well as what and how data is distributed and to whom. As noted in the artifacts, the design reflects the product team's decisions to support early adopter user needs. The artifacts reveal less about the impact of the team's interpretations of the relative importance of its expertise, interest in differentiating the product in the market, and regulations on its response to the uncertainty regarding designing the T6's data ecosystem.

Regarding user needs, the T6's public artifacts disclose: what and how the T6 collects data from multiple sensors, users' ability to import and export data, and what new, insightful information (EPOC and training effect) is distributed alongside familiar information to users. Including EPOC and training effect reflects the team's decision to differentiate the product in the market. These artifacts illustrate what data is collected and distributed in the T6's data ecosystem.

As a result of supporting early adopter user needs and the team assessing it was not expert to fulfill those needs, the data ecosystem featured contributions from Dynastream, Nordic Semiconductor, and FirstBeat. The T6's public artifacts do not reference Dynastream's presence in the data ecosystem, particularly how the company's technology is used to collect and wirelessly transfer data. Nordic Semiconductor is not referenced as the provider of the semiconductor chip within the watch. It is unknown why the team decided not to disclose the companies in the T6's public artifacts. Both Finnish KIHU - Research Institute for Olympic Sports and Firstbeat are disclosed as the providers of EPOC and training effect, conveying to users how their data is analyzed. While it is unknown why the team disclosed their names, it is reasonable to speculate that disclosing their names was done in an effort to establish credibility for the new information.

The T6's compliance with Finnish regulations is communicated to users, but not how two related decisions that surpasses regulatory requirements impacted the data ecosystem design. First, communicating the team's decision to not distribute users' data illustrates the boundaries of the T6's data ecosystem. Users could correctly infer from the statement that

¹³Finland 523/1999 Personal Data Act. <https://www.finlex.fi/en/laki/kaannokset/1999/en19990523.pdf>

their data is not shared with Firstbeat for analysis. Second, communicating that users may export their data signals to users their control over how their data is distributed.

Case evidence from the release stage supports that the product team's interpretation of the relative importance of user needs was the key determinant of its response to designing the data ecosystem. The artifacts offer minor support for the product team's interpretations of the relative importance of information economics and its expertise as determinants of its response, and do not support that the team's interpretation of the relative importance of regulations were determinant of its response.

4.5 Summary

Case evidence supports that the Suunto T6 product team's interpretation of the relative importance of user needs, particularly those of early adopters on the team itself, was the key determinant of its response to its uncertainty regarding designing the T6's data ecosystem. The data ecosystem design is depicted in Figure ?? on page ?. The team's interpretation of the relative importance of its expertise was a minor determinant of its response, as the team turned to outside companies for their expertise fulfilling the earlier noted user needs. The team's interpretation of the relative importance of information economics concepts, particularly differentiating the T6 in the market, was a minor determinant of its response. Case evidence does not support that the product team's interpretation of the relative importance of regulations was a determinant of the team's response.

The product team's decision to fulfill early adopters' need to collect data from multiple sources led the team in-part to partner with Dynastream for its expertise. The team also partnered with Nordic Semiconductor for its expertise developing a semiconductor chip for the T6 watch. With those decisions the team relinquished some control over what and how data was collected, and correspondingly what data was distributed, in the T6's data ecosystem. The related decision to allow users to import their activity data from other devices impacted how and what data entered the ecosystem, and effectively lowered the switching costs for users of competing products to adopt the T6.

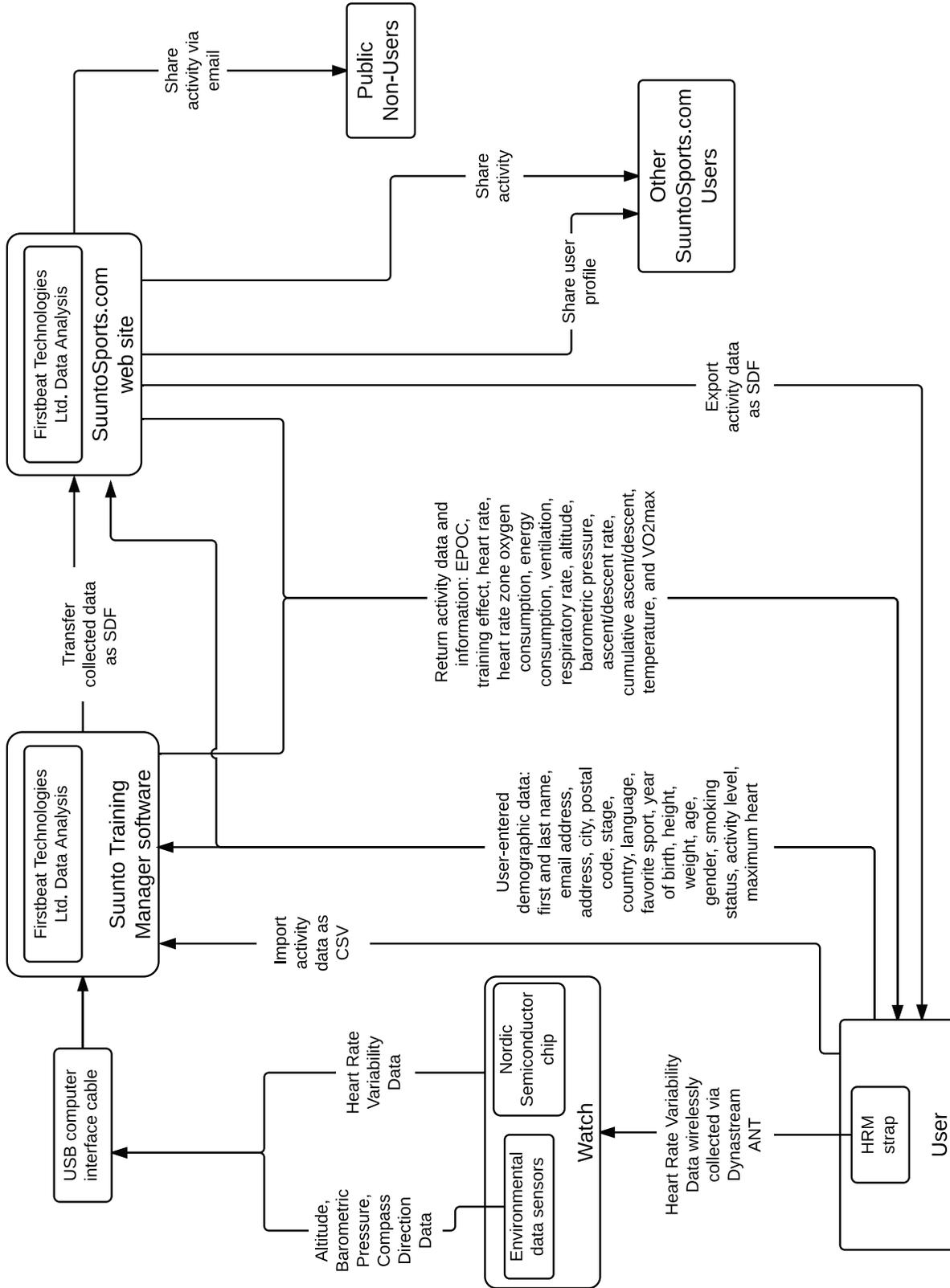
Fulfilling users' need for new, insightful information to improve their fitness led the team to partner with Firstbeat for its' EPOC and training effect. That information would differentiate the T6 in the market. As earlier, with the decision the team relinquished some control over what data was distributed in the data ecosystem. The differentiating feature would be reliant on Firstbeat.

The product team's decision to fulfill users' request to export their data impacted how data was distributed and to whom in the T6's data ecosystem. With this decision the team relinquished some control over the distribution of data in the ecosystem, and lowered the switching cost for users to transfer their data to a competing product. The product team's decision and public disclosure to not distribute data to third parties even though regulations permitted it with user consent, conveyed the boundaries of the T6's data ecosystem.

The design of the data ecosystem for the T6 enabled the flow of user data into the ecosystem from a range of sensors and with users' ability to import data, and out of the ecosystem back to users. This design reflects the product team's decisions to support early adopter needs regarding the collection and distribution of user data.

In summary, the Suunto product team's interpretation of the relative importance of user needs was the key determinant of the team's response to its uncertainty regarding designing the data ecosystem for the T6, followed by its interpretation of the relative importance of its expertise. The team's interpretation of the relative importance of information economics concepts, particularly differentiation, was a minor determinant of its response. Evidence does not support that the product team's interpretation of the relative importance of regulations was a determinant of its response.

Figure 4.1: Suunto T6 Data Ecosystem Design



Chapter 5

Garmin Forerunner 50, 2007

5.1 Introduction

Garmin was amongst the first companies to develop and release consumer-oriented global positioning services (GPS) devices. Formed by two engineers in 1989, the company's devices helped mariners, aviators, and outdoors people fulfill their location and navigation needs. The devices collected users' location data via GPS and displayed it on the device, either as a fixed point on a map or a sequence of points as a mapped route. Garmin's first instrumented fitness experience, the Forerunner 50, did not fulfill users' location needs.

Released in late 2003, the Forerunner 50 bundled a watch, wireless heart rate and running cadence sensors, and desktop software and web-based Connect service for viewing collected data. The Forerunner 50 analyzed users' heart rate and speed and distance, and returned such information as calories burned during an activity and heart rate zone. Users could import and export their fitness activity data, and share that data with friends and coaches. With users' consent, outside companies could access user data to create complementary services. Since the Forerunner 50 did not feature GPS it could not collect and display location and route data, unlike every device in the company's fitness product line since their launch in 2003.

The Garmin product team's response to its uncertainty regarding designing the Suunto T6's data ecosystem is jointly explained by the team's interpretations of the relative importance of user needs and information economics concepts. The response reflects the team's decisions to support early adopter user needs and introduce a low-cost device to the maturing fitness device market. The design also reflects the team's decision to spur demand for the Forerunner 50 through allowing third party developers to create complementary services with user data. The team's interpretations of the relative importance of its expertise and regulations were minor and non-determinants of its response, respectfully.

The Forerunner 50 is significant because the product team's decisions led to the vertical integration of the Forerunner 50's data ecosystem. The product team held control over the entire ecosystem, determining what data the ecosystem collected and how, as well as what

data and information the ecosystem distributed and to whom.

The case presents a history of the Forerunner 50 in three stages. During the concept stage the product team identified a potential business opportunity for what would become the Forerunner 50. The product team engineered and tested the Forerunner 50 in the development stage, and made it available to consumers in the release stage.

The case details and analyzes the product team's key data ecosystem design decisions during the concept and development stages. It assesses how those decisions impacted the data ecosystem design during those stages, as well as how those decisions manifest in the publicly released Forerunner 50's data ecosystem design. Figure ?? on page ?? depicts the data ecosystem design.

The case draws on two data sources. First, interviews with five key product team leaders and members responsible for bringing the Forerunner 50 to market. Interviewees include the Garmin Fitness Product Manager, a Garmin Training Center software engineer, MotionBased Technologies (and later Garmin Connect) Head of Product Management, MotionBased Technologies (and later Garmin Connect) Head of Engineering, and Dynastream Innovations Head of Personal Monitoring. Second, public artifacts, such as product documentation and marketing materials, distributed and/or created by Garmin and the two companies it acquired to create the Forerunner 50, Dynastream Innovations and Motion-Based Technologies. These artifacts were collected via the respective companies' web sites and the Internet Archive's Wayback Machine, which stores copies of public web pages and web-accessible media.

5.2 Concept Stage

The idea for what would become the Forerunner 50 emerged from within Garmin's Olathe, Kansas-based consumer devices product team. The team was formed in 2002 and tasked with creating fitness-oriented personal consumer electronic devices featuring the company's global positioning system (GPS) technology. In 2003 Garmin introduced the Forerunner 101, a wrist-wearable GPS watch that collected users' location and displayed it in real-time on the watch. The Forerunner 101 retailed for \$115.00.¹

A systems engineer on the product team was also runner, and expressed to Garmin management that the watch only fulfilled part of users' needs. Early adopter users like her needed the ability to view and interact with their collected data with desktop computer software. The company tapped this systems engineer to serve as the product manager for the company's emerging fitness product line.

The fitness product manager oversaw the introduction of the Forerunner 201 in late 2003, which collected users' location data and offered the ability to view their collected data on the watch or included desktop software. By 2004 the fitness product manager recognized shortcomings in the user experience, including:

¹Garmin Ltd. Garmin Unveils Low-Cost, GPS Fitness Product – the Forerunner 101. Marc 2, 2003. <http://www8.garmin.com/pressroom/outdoor/030204.html>

We had developed our own desktop software, but it wasn't enough. It didn't provide enough value. We were a GPS company, but yet, you couldn't see a map. It didn't make any sense. The most important thing, with the exception of speed and distance, was seeing where you went. – Garmin Fitness Product Manager

The fitness product manager explored adding such functionality to its desktop software, but found at the time that the cost to license such maps was prohibitive. As 2004 unfolded the fitness product manager found multiple companies offering web-based services allowing users to interact with their GPS-based location and route data. These web sites allowed users to view their movements on an engaging and detailed map. The team was inexperienced with developing such web-based technologies itself. The product manager identified five of these companies for potential partnerships, including San Francisco Bay Area-based four-person startup MotionBased Technologies.

Earlier in 2004 MotionBased created a web site where fitness enthusiasts could find and share places to hike, bike, and run. MotionBased's founders were experienced athletes and early adopters of fitness technology, and created the service to fulfill their own needs as cyclists and runners. The founders also engaged with local friends and colleagues to understand their needs and interests as athletes.

MotionBased users would wear their Garmin GPS-enabled device while exercising and then connect the device to their computer via their Garmin-supplied USB cable. A MotionBased application on their computer would import their activity data to the web site. MotionBased did not feature the ability to access data on non-Garmin devices, though users could import their existing activity data in the open GPX file format. The MotionBased site converted users' data into information about their exercise activity, such as their speed and a map displaying their route. Users could view this information, share it with other users, and as well as download their collected data to analyze themselves with spreadsheet software. The company offered users two service tiers.^{2,3} At that time in 2004 the Standard tier cost \$12 per month or \$96 per year and included unlimited uploads and storage, analysis, and access to all activities. The free Lite service tier limited activity access to users' ten most recent activities.

We were the very first web app to ever take a map as a base layer and then draw a red line on it and show you where you went. No one had ever done that. – MotionBased Head of Product Management

MotionBased described its target users:

We were catering to what I would call early adopters and the people that had adopted GPS as being their primary training tool to track their workouts. Es-

²MotionBased. Pricing. <https://web.archive.org/web/20051102220323/http://www.motionbased.com/info/product/view.mb?tile=info.product.pricing>

³MotionBased. Account Features Chart. <https://web.archive.org/web/20051102215934/http://www.motionbased.com/info/product/view.mb?tile=info.product.chart>

pecially MotionBased being just an initial launch, it had a lot more of the techy stuff. Of course my favorite term that somebody came up with was data porn. Those people love to – we really just pulled out every last correlation we could. We ended up having what I would describe as very fit male nerds. – MotionBased Head of Engineering

MotionBased did not design and manufacture its own devices to collect data, rather it relied on being able to access data collected on other companies' devices. The company reached out to the major fitness device companies, including Timex, Nike, Polar, Suunto, and Garmin, to ensure access to this data. MotionBased made the case to these companies that opening access to their devices' data would enable the companies to sell more devices.

Of these companies, MotionBased was particularly drawn to Garmin, who was experiencing success with its GPS-enabled wearable fitness devices. These included the earlier-cited Forerunner 101 and 201.

Garmin came out with these products that caught them by surprise at how successful they were. I mean, these took them to a whole new space. It was big. It was for early adopters. It was for people that were fitness techies. – MotionBased Head of Product

At the cycling-related Interbike 2004 trade show MotionBased proposed a partnership to the Garmin fitness product manager's supervisor.

Of everybody that really got it and understood the value of what the GPS could bring, Garmin really stood out. They made it happen. We helped them make it happen, really. We were tiny. We helped them see that they could sell bike computers. We brought them to our booth at Interbike. Just stand with us because you'll find out and you'll listen to what cyclists are saying about this stuff. They listened to that. – MotionBased Head of Engineering

Following the trade show Garmin invited MotionBased and three other companies offering similar web-based mapping services to its headquarters to discuss partnerships. Per the Garmin product manager, the company quickly chose to partner with MotionBased because of its expertise, the companies' shared mapping strategy, and because the service would help fulfill her vision of offering users a rich and interactive experience. The site would convert users' GPS data and plot it on a map, and provide a means to view and share their information with other site users. The product team immediately began promoting MotionBased by inserting a paper advertisement for the site in the box for each of its' fitness devices.

In October 2005 Garmin acquired MotionBased.⁴

⁴Garmin Ltd. Garmin Ltd. Acquires MotionBased Technologies. October 3, 2005. <http://www8.garmin.com/pressroom/corporate/100305.html>

By that time over 11,000 registered users had logged approximately 140,000 outdoor activities to the site. The MotionBased team described the motivation they saw for the acquisition:

We didn't see it for Garmin as being a revenue generating service. It was more of a service to make their hardware more usable, useful, and help sell more product. That would be the end game. – MotionBased Head of Product Management

With the acquisition the Garmin product team turned to the company's attorneys and regulatory team to ensure the MotionBased service complied with relevant regulations regarding the collection and use of personal data. As a company with products and services throughout the world, the team looked to relevant regulations in the United States and European Union.

With the acquisition it became a Garmin product, which was more international versus what MotionBased had been, which was a startup. We did all the checks and balances for regulations with our attorneys and regulatory team. – Garmin Fitness Product Manager

Prior to the acquisition the MotionBased team had not pursued such efforts to ensure regulatory compliance, instead relying on employees' personal beliefs and experiences regarding how users' fitness data could and should be used

I remember when I was with MotionBased we were worried sometimes. We're like, 'What should we do with privacy, since people's locations?' We ended up not dealing with it. Honestly, we just never heard it from people. No one really complained that vocally about those issues. Then with the heart rate data, sometimes we'd have to think like, 'Oh, what about HIPAA? Do we need to be HIPAA compliant and stuff like that?' I guess maybe it just felt like it was still like the Wild West. It was like, 'We don't need to deal with this.' – MotionBased, now Garmin Connect Head of Product Management

Garmin updated the MotionBased terms of service and privacy policies to ensure compliance with these international regulations, but did not make any changes to the MotionBased service in order to comply with these regulations. The team found that the site already complied with regulations, including allowing users to access their collected data, and did not distribute collected data to non-user third parties without users' consent.

With the acquisition Garmin maintained all of MotionBased's existing features, including users' ability to import and export their activity data. At first Garmin operated MotionBased as a standalone brand, but in 2006 the company changed the name to Garmin Connect to better fit the company's branding.

In 2006 Garmin became interested in introducing a low-cost non-GPS fitness device that would appeal to a new user segment for the company: people interested in tracking their

fitness though unwilling to spend hundreds of dollars on the company's existing higher-end GPS fitness devices. The proposed device would be the first in what the Garmin fitness product manager envisioned as an integrated system of watches, wireless sensors, and desktop and web-based software services.

The system would feature a simplified user experience, one that would ideally appeal to a broader set of users than the company's existing dedicated athletes and early technology adopters. Collected user data would seamlessly and wirelessly transfer from the watch to the Connect web site, formerly known as MotionBased, without the user connecting their watch to their computer via a cable. As described by the team's desktop software engineer:

This was a vision that was communicated to me by (the Garmin Fitness product manager). The idea is that after exercising the user comes in and tosses their watch on the desk. When they come back from getting a drink of water, their data is there available for them on the web site. The idea at the time was that we wanted this thing to be simple and automated. The user doesn't even know it's going on. They just completely forget about it. – Garmin Training Center Software Engineer

Garmin recognized that it did not have the expertise to develop the technology needed to wirelessly transfer collected data from the watch to the desktop computer and web site, as it had never developed such a technology itself.

Also at this time in mid-2006, Dynastream Innovations Inc., an original equipment manufacturer of fitness sensors, approached Garmin with its' new bundled fitness watch and sensors. Founded in 1998, Dynastream developed fitness sensors and then sold them to companies who wanted to offer their own fitness products but did not have an established brand or the needed development expertise. These technologies included heart rate monitors and foot pod sensors, as well as ANT+, a wireless protocol developed by the company specifically for transferring fitness data between electronic devices. Dynastream's head of personal monitoring described the company's business model:

We would do all of the development – the design and development and the manufacturing. Then we would ship them either a finished product directly to distribution or, more commonly, an OEM module that would be assembled into mechanics by the brand's contract manufacturer. – Dynastream Head of Personal Monitoring

For example, a company interested in selling consumers a fitness device would create its own system composed of their own watch bundled with Dynastream's sensors and utilizing Dynastream's ANT+ technology to transfer data between the two.

Garmin utilized Dynastream's heart rate monitor sensor and ANT+ wireless data transfer technology for its Forerunner 305 fitness device, which was released in January 2006. Garmin turned to Dynastream because its was inexperienced developing such technologies itself.

As an original equipment manufacturer, Dynastream frequently helped its customers troubleshoot watch and sensor system problems. These experiences provided Dynastream with insight and motivation to develop its own bundled watch and sensors system.

We called it the multi-watch and we developed a set of products including wrist-watch and sensors that were suitable for OEM customers. This allowed them to test one or more products as part of a complete system, before deciding to purchase. – Dynastream Head of Personal Monitoring

Dynastream felt its customers would want a low-cost system to appeal to consumers in the fitness device market. The market was transitioning from the early adopter stage of user-athletes such as triathletes to the early majority stage of more general fitness enthusiasts. The Dynastream head of personal monitoring described the target consumer-user and product offering:

The idea of the multi-watch was to offer a multi-sport device that could be worn by a range of users. – Dynastream Head of Personal Monitoring

With a functioning prototype in-hand, Dynastream approached Garmin and other companies about buying their new watch and sensors system.

The fitness product manager recognized that Dynastream's new watch and sensors system was targeted at the same early majority fitness users that the team planned to target with its new fitness system. The product manager decided that Dynastream's product would be the first device in that system.

In December 2006 Garmin acquired Dynastream.

Dynastream was already becoming vital to our business. We were using their accessories, their heart rate straps, and their wireless technology. We wanted to continue in this space, so Garmin decided to go ahead and acquire them. – Garmin Fitness Product Manager

Per the product manager, Garmin's acquisition was not a result of competitive concerns, rather a desire to quickly establish itself in the maturing fitness market.

This is the first thing that we could do, the quickest, the first product that we can integrate in this ecosystem that we're creating. Let's just go ahead and finish this out, and then, we'll develop the next GPS product with the same ecosystem. – Garmin Fitness Product Manager

In January 2007 Garmin brought together the Connect (formerly MotionBased) and Dynastream teams to fast track the development of a new product. The Forerunner 50 would pair Dynastream's watch, sensors, and ANT+ wireless technology with the company's existing desktop software and Connect web site to provide mainstream, early majority users

with an inexpensive system for collecting and analyzing their fitness data. The Forerunner 50 would collect and analyze users' heart rate data, but since it did not have a GPS sensor it could not collect location data. Without location data, users would not be able view a map displaying their route on Connect.

Concept Stage Summary

Evidence supports that the product team's interpretations of the relative importance of early adopter and early majority user needs and information economics concepts were key determinants of its response to uncertainty regarding the designing the Forerunner 50's ecosystem design during the concept stage. Evidence supports that the team's interpretation of the relative importance of its expertise was a minor determinant of its response, while evidence does not support that the team's interpretation of the relative importance of regulations was a determinant of its response.

Garmin's fitness product team was composed of early adopters of fitness technologies, including the systems engineer chosen by management to oversee the team. These users needed the ability to view their collected GPS-based location data as a route drawn on a web-based map. The team assessed that it was not expert to develop such functionality itself, so Garmin acquired MotionBased. The startup offered a service that analyzed and displayed users' fitness and related data, such as their heart rate on a mapped route, on a web site. The product team confirmed that the site complied with relevant international regulations, renamed it Connect, and marketed it alongside its existing fitness devices. The ability to view a mapped route on a web site differentiated Garmin's products in the market.

The fitness product manager envisioned creating a new system composed of watches, sensors, and desktop and web-based software for the maturing fitness technology market. The system would appeal to the company's existing early adopter and growing early majority user communities. Garmin management agreed with her vision. The product manager decided the first device would be an inexpensive product in order to appeal to early majority users. This decision is supporting evidence for the team's interpretation of the information economics concept of penetration pricing as a determinant of its response.

Garmin partner Dynastream approached the product team with an inexpensive watch and sensors that did not feature the ability to collect GPS-based location data. Garmin's existing fitness devices used Dynastream's data collection and wireless transfer technologies because the team was not expert with these technologies. Garmin acquired Dynastream in part for its' expertise, and because Dynastream's technologies would serve a key role in Garmin's planned fitness system.

The team decided to bundle the Connect service and desktop software with Dynastream's watch and sensors to create the first product in its' fitness system: the Forerunner 50. The decision reflects team priorities: quickly introducing an inexpensive product appealing to early majority users, continuing to support early adopters' need to import and export their data rather than supporting the early adopter need for viewing a web-based mapped route and differentiating the product in the market with that web-based map feature.

In summary, at this stage of the Forerunner 50's development case evidence supports the product team's interpretations of the relative importance of user needs and information economics concepts as the key determinants impacting the team's response to its uncertainty regarding the ecosystem design. The team's interpretations of the relative importance of its expertise and regulations were minor and non-determinants of the ecosystem design, respectively.

5.3 Development Stage

Development of the Forerunner 50 began in late January 2007, with efforts distributed amongst teams located throughout North America.

(The wristwatch) hardware and firmware was mostly done up in Canada at Dynastream. A large part of the productization of it and some engineering was done in Kansas (at Garmin headquarters). Desktop application development was done in Arizona and all of Garmin Connect was built in San Francisco. – Garmin Connect Head of Engineering

Before the Forerunner 50 could be released to the public the teams would need to make decisions about how to combine their respective pre-acquisition efforts into a cohesive system for their target users.

First, the teams jointly identified what information the Forerunner 50 would return to users. To kickstart this effort the Garmin product manager noted that the Forerunner 50 would feature at least the same information as available with the company's existing fitness devices, except location since the Dynastream watch did not include a GPS sensor. Given the accelerated product launch goal of fall 2007, the information would need to be collected via Dynastream's existing suite of sensors.

We had a foot pod for running, the bike sensor for cycling and the heart rate monitor for all of the above, as well as general fitness. – Dynastream Head of Personal Monitoring

Given these specifications and limiting factors, the teams determined that the returned information would include calories, cadence, heart rate, speed, distance, and heart rate zone.

Garmin gathered user needs through private interactions with a small community of employee-users, as well as individuals outside the company. The Dynastream team gathered user needs through similar private interactions with a group of local users as well as employees. Members of all groups were avid fitness enthusiasts and early adopters of fitness technologies.

These users provided information about their needs and evaluated product prototypes, including the watch that would become core to the Forerunner 50. These interactions occurred prior to and following Garmin's acquisition of Dynastream.

We recruited a group of users... a pool in our community that we would work with. Some of the people we'd worked with for years. – Dynastream Head of Personal Monitoring

Prior to the acquisition the Connect team did not interact with users in such a way, as the team had limited resources. Instead the four-person team relied on their shared personal needs and experiences and those of their friends to guide product and feature development. The Connect team also publicly solicited feedback from users on the Connect site's community forum, just as the team had done on its' pre-acquisition MotionBased site's forums.

We didn't have private testers, but once we came onboard with Garmin we were very adamant about trying to get feedback outside of the team. – Garmin Connect Head of Product Management

We had from the early days at MotionBased a very active forum that we would interact with Garmin customers. – Garmin Connect Head of Engineering

Through these interactions Garmin identified user needs and interests, including that users wanted the ability to import their own data and access to their collected data. Dynastream's head of personal monitoring cited a similar view regarding data accessibility, which was shared by Garmin's product manager.

We believe that the data belongs to the user. I don't think there was any feeling that we needed to keep the data from the user. Our users are very dedicated. They're very data driven. There are whole third party sites dedicated to post-processing Garmin data. I think that that is a feature of our users – that they really want to know about their data. So it was part and parcel of what we were providing as a product – that the data needs to be available and have good integrity.
– Dynastream Head of Personal Monitoring

These needs aligned with those already supported by Connect, so the product team decided that users would continue to be able to import and export their data.

The Forerunner 50's information capabilities were further shaped by Dynastream's interest in establishing its FIT schema as an improved format for storing and organizing users' fitness data. At that point in early 2007, two XML file schemas were primarily used to store users' fitness-related data. The GPX schema was introduced in 2002 and focused on storing users' GPS-based location data as a series of waypoints. The schema was freely available without licensing fees, and any company could adopt GPX to store data or adapt it to fit their needs.⁵

⁵GPX – The GPS Exchange Format. <http://www.topografix.com/gpx.asp>

Garmin introduced its TCX schema in 2007 to transfer GPS and fitness data between Garmin products, including its Training Center software.⁶ The TCX schema stored GPS-based location tracking data, as well as fitness-related heart rate, calorie, and lap data. Garmin publicly shared the TCX file schema and documentation, allowing other companies to adopt the schema. MotionBased adopted TCX and used this documentation to build its' service. Garmin did not allow companies to modify the TCX schema.

Dynastream found that the GPX and TCX formats produced large file sizes, which could not be quickly transferred using its new ANT+ wireless data transfer technology. The Forerunner 50 would need a smaller file.

The genesis of FIT arose from – what's the smallest, most efficient way that we can transfer a lot of data from the watch to wherever. We couldn't use TCX or GPX because inherently the Forerunner 50 wasn't a GPS product, so it didn't make sense to use them. FIT was designed to be very flexible, lightweight, and could go wireless through ANT+ . (Dynastream) had to be judicious at the time, because the first ANT+ wasn't super fast. They were just very smart about what types of data they would capture. They knew what a runner would want. – Garmin Connect Head of Product Management

The product team planned to use Dynastream's FIT file format to transfer data between the watch, sensors, and the user's computer. The company's strategy for adopting and promoting FIT served internal development needs.

The goal was to create a truly standard fitness data format and something that all the Garmin fitness devices could use. All (Garmin) fitness devices would speak the same language so that it simplified the supporting software. The Connect website wouldn't have to say this is a Forerunner 50, so I need to do this thing to import the data. You just say that's a FIT file. I know how to read that. It speeds development up and it makes it where your troubleshooting and your debugging are more focused. – Garmin Training Center Software Engineer

Dynastream's FIT was also conceived as a means to create value for ANT+ developers and end users. Through promoting FIT as a standard for other companies to adopt, users would be able to share their Forerunner 50 data with other systems. Such ability to share data was perceived as helping spur device sales.

That goes to market share, if your device can be used in multiple contexts, people are more likely to buy it than if it's just my device works on Garmin Connect. There were other websites that read stuff from Garmin devices. That increases the value of your product because you can have data analyzed in different areas, different groups. – Garmin Training Center Software Engineer

⁶Garmin. Training Center Database XML. <https://web.archive.org/web/20150523005207/http://www.garmindeveloper.com/schemas/tcx/v1/>

Dynastream would promote adoption of its FIT format through the ANT+ Alliance, an industry consortium founded by the company in April 2005, prior to its acquisition by Garmin. Dynastream founded the ANT+ Alliance in order to establish data and wireless transfer standards in the emerging fitness device market. Alliance members included Suunto, Timex, and other personal fitness device companies. ANT+ compatible devices could readily exchange data with one another.

As the leader of the ANT+ Alliance, Dynastream was in the position to promote the paired adoption of FIT and ANT+ amongst fitness device companies.

Dynastream wanted to push FIT, proliferate that file format to competitors, vendors, whomever, because they felt it was a superior file format. They were also trying to sell ANT+ and to get it adopted by as many people as possible in the industry. ANT+ was feeding the data that would be stored in FIT. – Garmin Connect Head of Product Management

The decision to adopt FIT in lieu of the GPS-oriented TCX schema for user data and forego GPS data entirely for the Forerunner 50 posed challenges for the Connect team.

We had designed the whole Garmin Connect system off of location. Our hero experience was the map and line showing where you went. – Garmin Connect Head of Product Management

The product team decided that Connect would need to be redesigned as a general fitness system, one that provided a valuable user experience whether or not a users' activity data included GPS. The primary interface would need to evolve from more than the map displaying routes to one that displayed information for a range of activities.

Changes to the Connect system to accommodate FIT and the non-GPS user experience were merged with already-underway Connect team efforts to re-architect the MotionBased system. Soon after the acquisition the Connect team identified the need to rebuild the system in order to make it more reliable and scaleable to support growing user volume.

When we did the transition from MotionBased to Garmin Connect . . . we re-wrote the app. We said, 'We can take a lot of the back end type of stuff, but it needs a whole new front end. It needs a whole new architecture. We need to scale.' – Garmin Connect Head of Product Management

The team rearchitected Connect atop a collection of application programming interfaces that would make the system more scaleable and reliable. The new architecture would replicate existing MotionBased functionality, better support Forerunner 50 users' interaction with their non-GPS data, and the new FIT schema. The site would primarily be built atop what the Connect team called the Connect API.

We developed Connect with a service-oriented architecture. Connect is just simply a web application that uses the Garmin Connect API. All things had to be done in the API. Very few things were done in Connect, the web application, that the API wouldn't provide. – Garmin Connect Head of Engineering

The Connect team pursued an API architecture in part for technical reasons, but more so for business reasons. APIs could be used by third party application developers to make complementary services, which the team believed would spur demand for Garmin devices.

Our premise ... was, 'Open up the data. Make it available to everybody, even our competitors. Just don't hold the data hostage. Let's sell as much Garmin products as we can, collect the data, and make it available to everybody.' – Garmin Connect Head of Product Management

Since MotionBased's founding the now-Connect team reached out to other companies, such as earlier with Garmin, to stay attune to changes in the emerging fitness technology marketplace. These companies were interested in accessing data stored on MotionBased, which at the time of the acquisition was a leading site for exercise and fitness-related data.

Prior to the acquisition RunKeeper and Map My Run – we would talk to them. They're like 'Hey, can we download files to Connect?' They wanted to have an API so they could pull data from Connect. We were working with them on that. – Garmin Connect Head of Product Management

The Connect team saw an opportunity to establish a powerful position for the company within the growing fitness market.

It's always been my thought... you build a very popular system if you – the more you open up the power of your product to others, they do less themselves and they become addicted to your product, right? Then you have – that just has power. – Garmin Connect Head of Engineering

The Connect team further saw opening the service and its data as a means to address feature requests that would appeal to niche users. Other companies could fulfill these requests.

Our whole thought, our whole idea was build something that's all things to all people. Because we knew that we were never gonna be able to do (everything). We knew that over time we would get all sorts of random feature requests. I remember it was harder for us, from a roadmap perspective. What features are we gonna implement? If you start to, you have this long tail of requests. It's just like, 'Well, it's easier for us just to build on a service that would allow that long tail of super eager developers to just do it themselves.' We're gonna focus the bulk of our stuff for the 80 percent. – Garmin Connect Head of Product

Garmin management and the fitness product manager supported making Connect's data available to third party developers to create complementary services, as long as doing so supported the company's strategy.

The company strategy was very simple. We wanted to sell hardware. If we felt like it enhanced it, then that was an easy decision to be made. – Garmin Fitness Product Manager

Garmin management voiced the need to focus on fulfilling the company's and users' needs over those of third party developers interested in creating complementary services.

It was our overall strategy of letting third parties utilize our data. We were first about the system working for us and then sharing that with others once we got it to a place that made sense. (Third party developers) were really wanting to be a part of us and a part of our products, and we were happy with that, but we were focused more on getting the customer experience and getting the different pieces working. I think it was kind of a, 'Sure, that's fine, but let's make sure our stuff works first' kind of strategy. – Garmin Fitness Product Manager

The Connect recognized this prioritization, while also striving to ensure the APIs could support third party developers' needs. To do so the team relied on the APIs while redeveloping the site for the Forerunner 50 launch.

Connect was built to be like eating your own dog food. The idea was that we had this API that we spent a long time building, just the whole back end, the infrastructure of the overall service. Then we wrote the front end of Connect on top of that using APIs. The idea was, 'Let's pretend that we're a third party. We'll build our front end on top of the back end. Let's see what we can do.' – Garmin Connect Head of Product Management

The Connect team experienced challenges, as at that time in 2007 developing web applications entirely atop APIs was a new practice. Connect's software developers needed to rethink their techniques and processes.

I had to really make a paradigm shift for all the developers that I was working with to say that you can't do that in the web, because you need to do that in the API because why? Other third parties are gonna want to use this same functionality, right? If you have something that needs to be done and it's valuable, let's make another end-point, or let's make this current end point better. That actually slowed down development because I wouldn't let everybody make it work however they wanted it to work. I would make sure that it was being done the right way because I had a future belief that the Garmin Connect API would service everybody in a very open system. – Garmin Connect Head of Engineering

The team faced further challenges due to those developers' inexperience:

We had a very young team that we had success hiring young and early – junior to mid-level engineers that essentially built all of Garmin Connect. They ended up doing a really great job in the end, but it took a little longer than expected. – Garmin Connect Head of Engineering

In light of these challenges the Connect team recognized that releasing the Connect API to third parties alongside the Forerunner 50's release was increasingly unrealistic.

I suppose in some ways it was coming even from internally in our own office in that we maybe weren't hitting all of the goals that we needed to be hitting for us to get our features implemented to get the MotionBased functionality migrated. – Garmin Connect Head of Engineering

The Connect team lowered the Connect API's priority amongst its development efforts, with the plan that it would revisit the Connect API after the Forerunner 50 release. The team focused on delivering the core functionality for Connect and supporting the development of additional devices in the product pipeline.

In May 2007 the product and Connect teams launched the Garmin Developer web site, where third party developers could learn about and discuss the site's APIs.⁷ The available APIs included those that the Connect team built prior to and following its acquisition, as well as those developed by Garmin. The APIs included the Garmin Communicator Plugin API to transfer data between web pages and Garmin GPS devices, the MotionBased User Interface Library for embedding maps in web applications, and the Garmin Device Interface SDK to transfer data between desktop software applications and Garmin's GPS devices. The site featured API documentation and sample code, and a forum where developers could pose questions and exchange ideas.⁸

Garmin's API License Agreement, which covered both the under-development and released APIs, detailed terms for using those APIs.⁹ The agreement provides no details of what could explicitly be done with the APIs, rather it specified restrictions against using the APIs to infringe on the trademark and patent rights of others and engaging in illegal or destructive activities. The agreement did not prohibit developers from using the APIs to create competing services. The online license file simply states:

⁷Garmin International. Garmin Publishes API Library and Opens Communication Between Third Party Websites and Garmin GPS Devices. May 29, 2007. <http://www8.garmin.com/pressroom/corporate/052907.html>

⁸Garmin International. MotionBased Web Services API. <http://web.archive.org/web/20071012201551/http://developer.garmin.com/web-products/web-services/>

⁹Garmin International. API License Agreement. <http://web.archive.org/web/20071101023200/http://developer.garmin.com/web-device/api-license-agreement/>

*You are free to access our API as long as you agree to create great things.*¹⁰

Also in early 2007 the Arizona-based desktop software development team updated the Training Center software to accommodate the FIT file format. The team developed the ANT Agent desktop software to wirelessly transfer data from the watch to the user's computer via a USB stick, and updated the firmware on the Forerunner 50 watch. The team also contributed to the Communicator Plugin API, which allowed third party web sites to access data on the Forerunner 50.

The Dynastream team focused on engineering the watch and sensors for large scale production.

Once the Dynastream, Connect, and Training Center components of the Forerunner 50 reliably collected and exchanged data, the teams began interacting with users about various aspects of the experience. The Kansas-based product team distributed paper-based surveys and feedback forms to its employee-users, as well as a private group of nearby external users. These users included early adopter and early majority users. The Dynastream team continued its' pre-acquisition efforts of proactively interacting with its private group of local users, particularly to assess the usability of the watch's interface and the accuracy of their data analysis.

We worked with users to not only measure the accuracy over a range of users, but also to see how people worked with the user interface. There are always decisions of how to make the product fully-featured, but at the same time not too technical to use. – Dynastream Head of Personal Monitoring

The Connect team was likewise interested in users' experiences with the device and service, as well as the accuracy of the analysis. The target users for the Forerunner 50 were different from the company's pre-acquisition users, which meant the team needed to rethink how it would engage with users to collect feedback.

We had to take a different approach and say well, these (Forerunner 50) users aren't going to be coming (to the forums) and informing us of all the different little things that they like or dislike. They're just gonna stop coming, right? Because that's what the mass market does. If it doesn't work or it's not intuitive, then they just leave. – Garmin Connect Head of Engineering

During the development stage the Connect team recruited an external group of users, sent them prototypes for evaluation, and assigned them activities. Users shared their experiences on a private web forum.

¹⁰Garmin Developer License File. <http://web.archive.org/web/20130125064948/http://connect.garmin.com/proxy/activity-search-service-1.2/LICENSE.txt>

All of our real power users that we would love to interact with, we sent them prototypes to try things out, and then give us feedback. Then we would get feedback from anything from how it compared to another device, because oftentimes they would have multiple devices that they would run with, to how did it interact with the system? Was it easy to set up? We would work with specific power users. – Garmin Connect Head of Engineering

We had tester forums that were private. We would post, ‘Here’s your assignment for this week.’ It would be sometimes from the hardware team or something it would be from the Connect team. We’d ask them to do this and then look at the data. – Garmin Connect Head of Product Management

These activities were used as usability assessments and to collect users’ data for analysis by the Connect team.

The primary purpose of those tests was to just get those products out to different people, different environments, and understand what’s going on with the data. – Garmin Connect Head of Product Management

By late summer 2007 the Forerunner 50 was ready for release.

Development Stage Summary

The product team’s interpretations of the relative importance of early adopter user needs and information economics concepts continue to be key determinants of the team’s response to its uncertainty regarding designing the Forerunner 50 data ecosystem. With regard to the former, during the development stage the ecosystem evolved to allow data to be distributed to both users and third party developers. Evidence does not support that the team’s interpretations of the relative importance of regulations or its expertise were determinants of the team’s response.

The Connect team redesigned the site to support growing user volume and to better fulfill Forerunner 50 users needs, which did not include mapping their GPS data. The team took advantage of this opportunity to rearchitect the site atop application programming interfaces. These APIs would better allow the site to scale with user growth, and would further the Connect team’s goal of making data available to third party developers to create complementary services. The Connect and product team believed that these services would spur sales for the Forerunner 50 and Garmin’s other fitness devices. This belief is further supporting evidence for the team’s interpretation of the relative importance of information economics concepts as a determinant of its response.

The Connect team encountered challenges developing the needed application programming interfaces. Garmin and the product team advised the Connect team to prioritize fulfilling internal needs, including support for several fitness devices to be released soon after

the Forerunner 50. With the product team's guidance, the Connect team decided not to publicly release all of the APIs. The Connect team's efforts would support limited complementary services with the Forerunner 50's release, while laying the foundation for future expanded complementary services in the data ecosystem. The team's decision to not release all of the APIs tempers evidence for the team's interpretation of the relative importance of information economics concepts as a determinant of its response.

In summary, case evidence at the end of the Forerunner 50's development stage supports that the product team's interpretations of the relative importance of user needs and information economics concepts continue to be the key determinants impacting the team's response to its uncertainty. The team's interpretations of the relative importance of regulations or its expertise were not determinants of its response at this stage.

5.4 Release Stage

Garmin announced the Forerunner 50 in August 2007 at the Outdoor Retailer industry trade show and released to the public in October 2007.¹¹

The retail packaged Forerunner 50 included the watch, a USB ANT stick to transfer data from the watch to the user's computer, and either the ANT+ compliant chest-worn heart rate monitor, foot pod sensor, or both monitor and sensor. These were priced at \$99, \$149, and \$199, respectively. For comparison, Garmin's existing, GPS-oriented Forerunner 205 and 305 fitness devices were priced at \$249 and \$349, respectively.¹² Competing devices by Polar with and without GPS features were priced at \$499 and \$199, respectively.^{13,14}

The Quick Start Manual and Owner's Manual provided abridged and detailed instructions, respectively, for using the Forerunner 50. These print materials directed users to download the Training Center software and Garmin Connect service package to transfer their data to Training Center and Connect service. The box included an insert card detailing the features of Garmin Connect. The back of the watch featured logos indicating its compliance with Federal Communications Commission and European Commission consumer electronics regulations, and ANT+ Alliance interoperability guidelines.

With regard to the data collected by the Forerunner 50, Garmin's public materials describe the device as recording heart rate, speed, and distance. The Owner's Manual notes that users may disclose their weight and gender, but does not disclose how that collected data is used by the Forerunner 50 or Connect. Garmin's Privacy Policy notes that it "only

¹¹Garmin Limited. Garmin Introduces Forerunner 50 As Only Sports Watch With Automatic Wireless Sync. August 8, 2007. <http://www8.garmin.com/pressroom/outdoor/080807.html>

¹²Garmin Limited. Garmin Introduces Forerunner 50 As Only Sports Watch With Automatic Wireless Sync. August 8, 2007. <http://www8.garmin.com/pressroom/outdoor/080807.html>

¹³Gear Junkie. Polar RS800G3 System Review. December 4, 2007. <https://gearjunkie.com/gear-review-polar-rs800g3-multisport-training-system>

¹⁴Polar USA. Polar Celebrates 30 Years Of Innovation with Launch of Activity Watch to U.S. Market. May 51, 2007. https://www.polar.com/us-en/about_polar/press_room/activity_watch

collects personal information about (users) on the Garmin Connect website if (they) voluntarily choose to share it with Garmin.” If a user chose not to sync their watch to their computer, no personal information would be shared with Garmin. Users could also import their existing activity data.

Garmin provided users with various types of control over their collected data. Users were able to download their collected data via Connect in a comma-separated value (CSV) format, which could be opened with desktop spreadsheet software.

Per the Privacy Policy, users could contact the company by email to change their personal information, such as their name and email address. Users could control whether their Connect profile and activities information were publicly available or private. Users could control whether each activity was public or private. Users had lesser control over other information they voluntarily shared about themselves on Connect. For example, exercise routes, name, and mailing address could be used by Garmin for internal marketing research and emailing users about “special promotions and other programs of interest.”

The company’s Terms of Service note “information, text, files, links, attachments, software or other materials“ users post on the public portion of Connect, which it deems “content,” becomes Garmin’s property. The company asserts it has perpetual and irrevocable rights to that content. It is unclear if this content includes users’ personal, Forerunner 50-collected data. The Terms of Service does not reference any regulations, such as those in the European Union or United States.

Lastly, Garmin discloses in the Privacy Policy that it never sells e-mail addresses to third parties. The policy does not specify whether other personal data may be for sale, or what should happen to users’ data in the event that the company is sold. The policy welcomes users to submit questions and comments regarding security and privacy via email to webmaster@garmin.com. As with the Terms of Service, the Privacy policy does not reference any regulations.

Garmin materials disclose how it collected users’ data via sensors, and that the wireless data collection complies with European Union Directive 1995/5/EC. The directive details regulations for radio equipment and not personal data.¹⁵ The User’s Manual references the “2.4 GHz/Dynastream ANT+ Sport wireless communications protocol” for the watch and sensors, but does not disclose that Garmin owns Dynastream.

Garmin does not disclose to users how it analyzes their collected fitness data. For example, details are not provided regarding how it calculated calories, or how it processed erratic foot pod and heart rate monitor data to remove anomalies. Garmin disclosed the accuracy of the Forerunner 50’s foot pod sensor, as well as how to improve the sensor’s accuracy. The User Manual noted that the accuracy of the foot pod sensor and heart rate monitor may be degraded by various environmental conditions, such as poor sensor contact and extreme temperatures.

Garmin’s public materials do not provide a detailed list of the information provided to

¹⁵European Union Directive 1999/5/EC. <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31999L0005>

Forerunner 50 users. The User Manual includes total run time, total distance, total steps, total calories, time in each heart rate zone, average lap time, average lap speed, average heart rate. Heart rate zones are described as a sequence from 1 (low) to 5 (high), with the corresponding percentage of maximum heart rate for each zone, perceived exertion level, and benefits of exercising in that zone. The company made no assertion that the Forerunner 50 is or is not a medical device, rather it advised users to consult a physician before they begin or modify any exercise program.

Garmin provided users with a variety of controls over how their data could be shared with third parties, including marketing partners, fellow Connect users, and the public. In its privacy policy the company stated that it would not “share, rent or sell information concerning subscribers or other users of the Garmin Connect website to third parties in ways other than disclosed” in the policy. The policy specifies six conditions for sharing user information with third parties.

First, with users’ consent. Second, if required by law, “such as in response to a court order or subpoena.” Third, if it finds the user is in breach of the terms of service. Fourth, to “prevent, investigate, detect, or prosecute” criminal attacks on the company and Connect service. Fifth, in order to protect the “rights, property, or safety of Garmin or its employees, the users of its website(s), or the public.” Sixth, when necessary to fulfill a “product or service order”, in which case the company shares relevant user information with a third party credit card processing company. That company “does not retain, share, store or use (users’) personally identifiable information for any other purposes.” The policy does not disclose what will happen to user information should the company be acquired by another company, or in the case the company goes bankrupt.

Through Connect users could share their fitness activities with fellow users and public non-users. For the latter, users could share a specific activity by copying and pasting the activity’s web URL, and then sharing that address with others. The respective fitness activity must be set as publicly viewable and not private to the user.

While the Garmin Connect API was not publicly released with the Forerunner 50, the existing Garmin Communicator Plugin API, MotionBased User Interface Library, and Garmin Device Interface SDK were available to third party developers. With users’ permission, these developers could access users’ collected data and display it on web sites and desktop applications.

Release Stage Summary

The product team’s interpretations of the relative importance of user needs and information economics manifest in its response to designing the Forerunner 50’s data ecosystem, as disclosed in the company’s public product-related artifacts.

The Forerunner 50’s price and feature set reflects the product team’s decision to introduce a low-end, inexpensive product. When compared with Garmin’s existing fitness devices and competing products in the fitness market, the Forerunner 50 is lower-priced with reduced features. The Forerunner 50’s price relative to competitors in the market is supporting

evidence for the team's interpretation of the information economics concept of penetration pricing as a determinant of the data ecosystem design.

The product team's prioritization of early majority over early adopter users' needs is reflected in the Forerunner 50's lack of GPS and online mapping, though the design supports early adopter users' need to import and export activity data. This is supporting evidence for the product team's interpretation of the relative importance of user needs as a determinant of the team's response.

The release of multiple application programming interfaces alongside the Forerunner 50 signals the product team's belief that third party developers' complementary services could spur sales, creating value for users, developers, and the company. The user-facing public artifacts do not cite the availability of the services, perhaps because not all of application programming interfaces were released with the Forerunner 50. The artifacts do not support the product team's interpretation of the relative importance of information economics concept of cross-side network effects as a determinant of the team's response.

Garmin's decision to acquire two companies to create the Forerunner 50 is minimally reflected in the Forerunner 50's public materials. MotionBased was rebranded as Garmin Connect, and Dynastream is disclosed without context in the User's Manual. The artifacts do not support that the team's interpretation of the relative importance of its expertise was a determinant of its response.

With the Forerunner 50's release, case evidence in the form of public artifacts supports that the product team's interpretation of the relative importance of user needs was the key determinant of the team's response, with the team's interpretation of the relative importance of information economics concepts a minor determinant. Public artifacts in the release stage do not support that the product team's interpretations of the relative importance of its own expertise or regulations were determinants of the team's response.

5.5 Summary

Case evidence supports that the Garmin product team's interpretations of the relative importance of user needs and information economics concepts were key determinants of the team's response to its uncertainty regarding designing the Forerunner 50 data ecosystem. The team's interpretations of the relative importance of its expertise and regulations were minor and non-determinants of its response, respectively. Figure ?? on page ?? depicts the data ecosystem design.

The team's concept stage decision to support early adopters' need to view a mapped route led Garmin to acquire MotionBased for its expertise offering such functionality. With that decision the product team controlled Connect, the key means for analyzing and distributing data in the Forerunner 50's data ecosystem.

The concept stage decision to introduce a low-cost device to appeal to and fulfill the needs of early majority users in the maturing fitness technology market led Garmin to acquire Dynastream. The product team then controlled how and what data was collected and

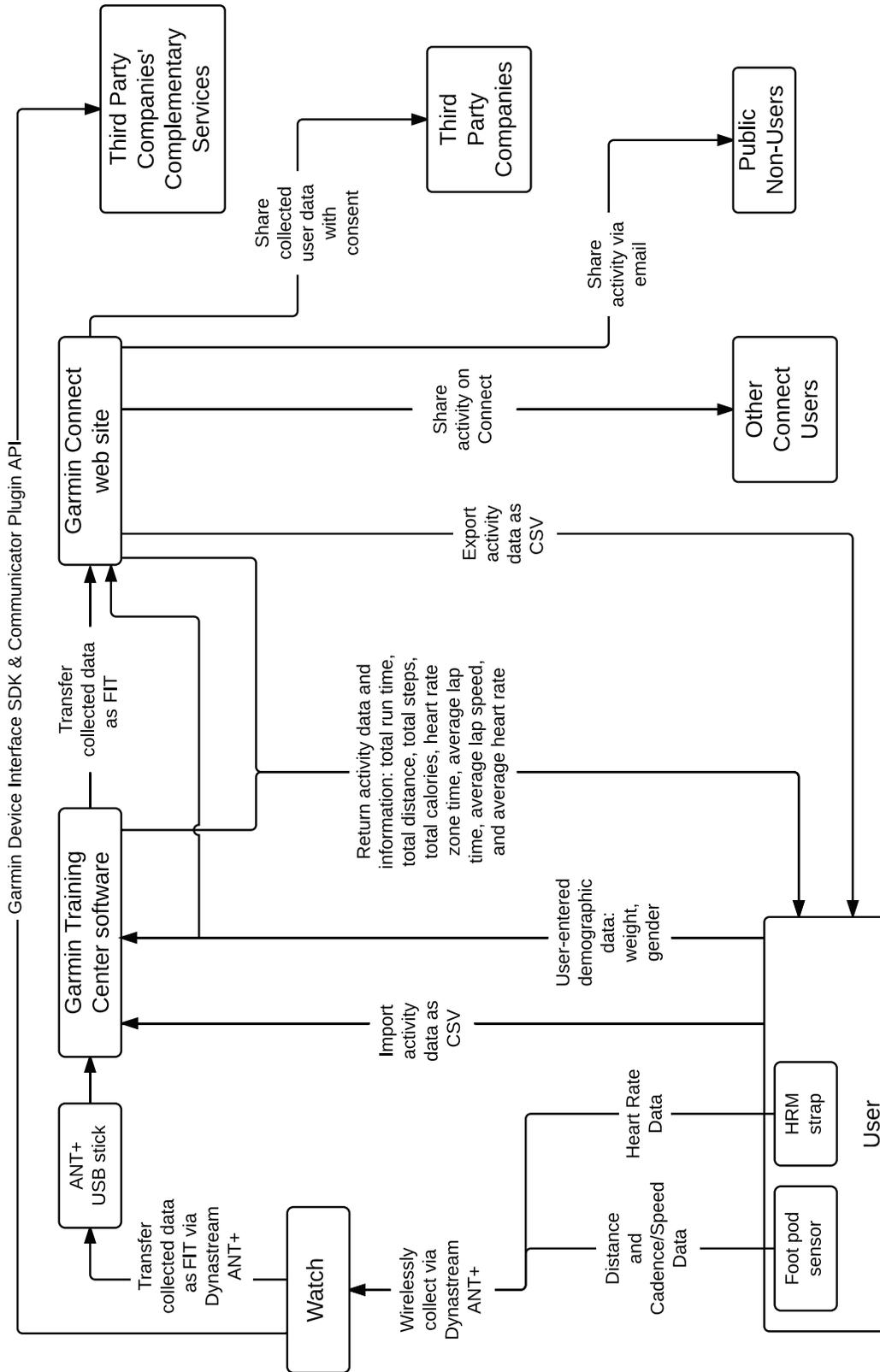
transferred in the Forerunner 50's data ecosystem. With that decision the Forerunner 50 did not collect GPS data, and the ecosystem did not feature the mapped route requested by early adopter users. The company did not disclose in its public artifacts that it acquired these two companies to create the data ecosystem.

The data ecosystem design evolved during the development stage. The team's decision during that stage to spur demand for the Forerunner 50 through allowing third party developers to create complementary services with user data led the team in part to redevelop Connect atop APIs. While not all of the APIs were publicly released with the Forerunner 50, the product team laid the foundation for the data ecosystem to feature third party developers' complementary services. The public artifacts do not highlight the role of complementary services, perhaps because the needed application programming interfaces were not ready when the Forerunner 50 was released.

The first two decisions led to the vertical integration of the Forerunner 50's data ecosystem. The team controlled what data the ecosystem collected and how, as well as what data and information the ecosystem distributed and to whom. The third decision expanded the data ecosystem to include third party developers and their complementary services.

In summary, case evidence supports the product team's interpretations of the relative importance of user needs and information economics were key determinants of the team's response to its uncertainty regarding the designing Forerunner 50's data ecosystem. The team's interpretations of the relative importance of its expertise and regulations were minor and non-determinants of the team's response, respectively.

Figure 5.1: Garmin Forerunner 50 Data Ecosystem Design



Chapter 6

Adidas miCoach Pacer, 2010

6.1 Introduction

Adidas was founded in Germany in the late 1940s to fulfill athletes' performance needs. The company develops professional and consumer-oriented footwear, apparel, and equipment for athletes participating in individual and team sports, including running, fitness, baseball, and soccer. The Adidas Innovation Team (AIT), an internal group of product managers, engineers, and designers, developed the company's miCoach Pacer instrumented fitness experience.

Released in January 2010, the miCoach Pacer collected and analyzed users' heart rate and cadence data. It returned data to users via the miCoach web site, and delivered real-time personalized audio-based coaching information via a device that integrated with users' existing music players. Users could share their exercise activities on Facebook.

The key determinant of the team's response to its uncertainty regarding designing the miCoach Pacer's data ecosystem was the team's interpretation of the relative importance of user needs. The team's assessment that it did not have the expertise to fulfill specific user needs led it to turn to outside companies for such expertise, supporting the team's interpretation of the relative importance of its expertise as a minor determinant of its response. One of those user needs differentiated the miCoach Pacer in the market. The team's interpretations of the relative importance of information economics concepts and regulations were minor and minimal determinants of the team's response, respectively.

The miCoach Pacer case is significant because though AIT relied on other companies' expertise for much of the ecosystem design, it exerted control over that ecosystem. AIT's decisions led to a data ecosystem featuring the expanded flow of data into and limited flow of data out of the ecosystem.

The case presents a history of the miCoach Pacer in three stages. During the concept stage AIT identified a potential business opportunity for what would become the miCoach Pacer. AIT engineered and tested the miCoach Pacer in the development stage, and made it available to consumers in the release stage.

The case details and analyzes AIT’s key decisions during the concept and development stages. It assesses how those decisions impacted the data ecosystem design during those stages, as well as how those decisions manifest in the publicly released miCoach Pacers’s data ecosystem design. Figure ?? on page ?? depicts the data ecosystem design.

The case draws on two data sources. First, interviews with seven key individuals who brought the miCoach Pacer to market. Two interviewees were members of Adidas’ Innovation Team (AIT), including the team leader and user experience designer. Five interviewees were employees of Molecular, the digital design agency AIT worked with to create the miCoach Pacer. These Molecular employees include the account manager responsible for the Adidas relationship, engineering leader, user experience leader, program manager, and interaction designer. Second, public artifacts, such as product documentation and marketing materials, distributed and/or created by Adidas. These sources were collected via various web sites and with the Internet Archive’s Wayback Machine, which stores copies of public web pages and web-accessible media.

6.2 Concept Stage

The genesis of what would become the Adidas miCoach Pacer began several years before its 2010 release. In the early 2000s Adidas formed a small innovation team (Adidas Innovation Team, “AIT”) and chartered it with developing new shoe and apparel products and technologies. While Adidas was headquartered in Germany, AIT had offices in both Germany and at the company’s United States’ headquarters in Portland, Oregon. Per the AIT leader, the small team operated as a startup within the larger Adidas brand.

Our innovation team acts as a startup with the brand and that is key because you get the benefits of a startup in that people are all hands on deck. – AIT Leader

As described below by the AIT leader, the team strove to identify new product opportunities by discovering user needs and creating means to fulfill those needs before users identified those needs themselves.

The way I run the innovation team is not to just go out and look at all the competition, make a feature list, and figure out how to beat them. It’s to look at the space and say where is the opportunity? Where’s the white space in here that people really need and they don’t know they even need? – AIT Leader

AIT developed and released products under rapid timeframes, particularly when compared with norms for the apparel and shoe industry at the time. AIT products were typically developed and released in eighteen month timeframes. In 2004 the team released the “1” running shoe, which automatically adjusted cushioning for the wearer.

In 2006 AIT identified an opportunity to apply the company’s expertise with fitness and consumer sports to emerging Internet and mobile phone technologies. AIT envisioned

developing a new digital fitness experience for consumers, one focused on a mobile phone, web site, and network of connected sensors to collect users' fitness data. The experience would provide fitness-related information to users. The concept arose from AIT's assessment of user needs, particularly of early adopters on the team itself. AIT recognized that neither it or Adidas had the technologies to fulfill those needs, and that developing the technologies it perceived it needed for this concept were outside the team's core competencies and expertise.

AIT reached out to mobile phone manufacturer Samsung with this concept. Such outreach may have been guided by Adidas competitor Nike's collaboration with Apple, which led to the release of the Nike+iPod digital fitness product of May 2006. While it is unclear why AIT chose Samsung, we can reasonably speculate that it sought a company with experience developing mobile consumer technologies.

The AIT leader turned to the company's Amsterdam-based digital marketing team for assistance with the web site aspect of the concept. The digital marketing team cited that developing such a concept was beyond their capabilities, and recommended that AIT contact Boston, Massachusetts-based digital design consultancy, Molecular. The digital marketing team was familiar with Molecular's efforts developing and managing Internet-based advertising campaigns and web sites for other companies.

In December 2006 AIT shared the digital fitness experience concept with Molecular. As recalled by Molecular employees who participated in these early meetings, AIT's concept fulfilled user needs that AIT did not have the technical expertise to fulfill itself.

There was this notion within Adidas already about what they called sports electronics, and they had a vision already for what they called a network of interconnected sports devices. It was very much about how do you bring the world of consumer electronics to the world of sports, and the products that they already had in mind.
– Molecular User Experience Leader

(Adidas brought) the concept behind its hardware technologies. They had Samsung, they had the heart rate sensor and stride sensor they were developing. They had these concepts clearly in mind and they were missing the other part... the web technology. – Molecular Account Manager

AIT quickly forged a contractual agreement with Molecular to collaboratively advance the concept. Per the Molecular employee later responsible for managing the project, AIT chose Molecular for several reasons:

At that point, it didn't make sense, and there was no interest (within AIT) to build (Internet technology) expertise, given that it was such a big difference from what they've been doing (with shoes). They needed someone else who was expert in web technologies. – Molecular Account Manager

In January 2007 the teams jointly undertook creating a detailed proof of concept, one identifying the overarching user experience and technical components needed to support their

digital fitness vision. AIT would use this proof of concept to guide their strategic thinking, as well as a tactical means to persuade Adidas for resources.

Molecular assigned four senior-level employees to the project, each bringing unique skills and knowledge to the project. The engineering and user experience leads oversaw the technical and user experience design aspects of the concept, respectively. Two other members oversaw the AIT-Molecular project and overall relationship, respectively. AIT assigned much of its small team to the project. All of the AIT members were experienced athletes, while Molecular members at this point were relatively less experienced or non-athletes.

Between January and March 2007 AIT and Molecular identified key user experience related aspects of the concept and defined the target user for the concept. These aspects and definitions arose from the team members' personal experiences and a research study with users outside the teams.

The teams conducted a research study of a survey and interviews with a group of users outside AIT and Molecular. As described by Molecular's user experience leader:

In 2007 we had the opportunity to do a little research project. We spoke to consumer athletes in Germany, the United States, and China, just to get a sense of what motivated them, how did they go about their exercise, and how did they get support and motivation, and what kind of communities they were involved in. That was probably the most direct contact that we had with users in the early stages. – Molecular User Experience Leader

The teams selected users in the United States and Germany for the study because they matched the company's primary countries of operation. China was selected in order to introduce a diverse viewpoint, one that the teams perceived was a rapidly emerging and potentially valuable market.

These personal experiences and findings from the user study surfaced a number of potential key user needs. AIT provided additional guidance to focus their efforts, including that the product would focus exclusively on running as the company was knowledgeable about the sport. Any eventual product would be available globally, since Adidas was a global company. The user experience would focus on a heart rate-oriented training experience, where the user's heart rate would be collected via a chest-worn heart rate monitor, in order to improve their fitness.

AIT chose heart rate because it was a democratic, egalitarian measure of fitness. It didn't matter if you were fast or slow, you could benefit from the same coaching model based on effort alone. – AIT User Experience Designer

Based on their personal experiences and the user study, the teams determined that coaching would be another central aspect of the proposed concept.

Everyone on the team had been through the experience of making running a part of your life and failing. Most of the time it's because you don't know how far to run or how fast to run. – AIT Leader

The teams explored ways to address their shared failures, beginning with providing users with information about how to exercise. In examining competitors' offerings and reflecting on their own experiences, the AIT leader found:

(The competition) were just all about the data, but a lot of people didn't have the training knowledge to actually be able to go out and start doing it on their own and be successful. It's that New Year's resolution failure that we targeted as our use case. – AIT Leader

With this use case the teams focused on defining their target user for the concept: individuals who were new or less experienced with running. AIT further decided that the concept would target beginning runners.

The teams realized that simply providing these target users with raw data would be insufficient for those users to achieve their fitness goals, as the users would be unfamiliar with what to do with the data. The proposed system would instead impart knowledge to users, leading to a unifying theme for the concept. From the user perspective, the concept would serve as “my coach,” which AIT branded “miCoach.”

The teams identified that this knowledge existed with coaches, however it was largely inaccessible to users. It was hard to find a coach nearby, communicate with that coach, and afford his or her services. The proposed concept would provide users with such coaching information, ideally in real-time while running. The AIT leader described the concept:

The only thing we'll ask of a user is to show up and miCoach will take care of the rest. Turn it on and we will guide you through your whole workout. Just show up and turn it on, and we will guide you through your whole workout. It'll be 30 minutes; then you'll be done. Then you can go home and not worry about it anymore. – AIT Leader

The concept would feature users' personal music, as team members cited its important role in their experience. The AIT leader envisioned that real-time coaching would differentiate the product in the market.

We viewed what we were doing as different from what was in the market because of the real time coaching. That's where we believed the value of what we created is, so envisioning the (F110 miCoach), we pretty much believed that most people wanted to run with music. We needed to figure out a clean way to get our coaching into their music. – AIT Leader

The teams determined that they would integrate coaching into the experience through simple voice commands, instructing the user to speed up or slow down their pace to then moderate their heart rate.

The study also revealed users' interest in social support and community-related features. For example, users' ability to share their experiences with others in order to maintain interest and motivation to exercise.

We felt that since was going to be virtual, community was going to be one of the huge ways that people would get and stay motivated. Community was integrated via the forums and opportunities to share on Facebook. – Molecular User Experience Leader

Throughout this proof of concept phase the team focused on the role of data in the user experience for beginning runners: what data the system would collect from users and what information it would return. The varying personal experiences with fitness and exercise between AIT and Molecular contributed to different views about what data would be useful for beginning runners.

(AIT) knew what data runners wanted. I think, and people might disagree with this, but I think there was always a tension between data for what we would call an athlete, who is somebody who is not a beginner, somebody who really is fit and trains, who competes, versus a consumer exerciser. A consumer exerciser and professional athlete are quite different. – Molecular User Experience Leader

Engineers on the Molecular, AIT, and Samsung teams collaboratively designed the technical aspects of the user experience: collecting users' data, storing and analyzing the data, and returning information to users. One theme bridged the user experience and technical aspects of the proposed concept.

There was a shared philosophy within the team...we always visioned that miCoach would be an open platform. We wanted to make our data open and available... (and a platform) that didn't exclude anyone. – AIT Leader

AIT decided that miCoach.com would be an open platform where fitness enthusiasts, regardless of the device they used to collect their data, could upload their fitness data and receive coaching guidance. Users would be able to download their collected data and analyze it in other services, even those offered by competitors. The AIT leader saw such platform openness as related to user needs:

We felt like if people wanted to come to miCoach, they should be able to come from wherever they were, and if they wanted to leave and go somewhere else, then we should learn from that. We should not keep the consumer captive because (they wanted to leave). That came from my belief that you always want to build an honest relationship with your user and that honest relationship doesn't come with handcuffs. – AIT Leader

AIT's vision of inclusion extended to third party developers, who would be able to create complementary services that analyzed users' collected data. Third party developers would access data on miCoach.com through application programming interfaces developed by Adidas. Users would then have the opportunity to grant these services access to their collected data on miCoach.com. These third party developers' services could help fulfill user needs.

AIT recognized that offering an open platform posed risks. Allowing users to easily download their data would lower their switching costs, whereby users could move their data to competing services that could then eclipse miCoach. The AIT leader envisioned the potential impacts of an open platform in the early stages of the digital fitness domain. As he describes, an open platform would benefit users, the company, and competitors:

We wanted to bring the world together in this vision. We felt like together we'd all be more powerful than we would be individually. – AIT Leader

As part of that open platform vision the teams interacted with potential third parties, such as regarding storing the vast quantities of users' collected data. The teams met with Microsoft's emerging HealthVault group, but opted for Adidas to store the data itself. Per Molecular's engineering leader:

(Microsoft's) idea was we're giving you the database and the application programming interface, which guarantees the privacy and security of health and fitness-related information for consumers, and it will be a platform to share that data in a sensible and protected way between providers.

For a number of reasons, that didn't work out. They were insisting that Microsoft will own the identity of our user and the authentication experience, and that just wouldn't work out for Adidas, so we backed out. – Molecular Engineering Leader

AIT did not include Microsoft in the data ecosystem because it did not want to relinquish control over its users' identifies. We can reasonably speculate that the team was also concerned that HealthVault may not fulfill users' needs in the same way that AIT envisioned. The AIT leader may have perceived that Microsoft's vision of platforms and value creation conflicted with his earlier-stated vision, particularly with regard to the importance of an open platform at the perceived emergence of the digital fitness domain.

By mid-2007 AIT and Molecular finalized their proof of concept: it would target beginning runners interested in improving their fitness, provide those users with real-time coaching information and personalized workouts, feature their music, and a means to interact with their data on a web site. Users' heart rate and stride data would be collected and wirelessly transferred to a Samsung mobile phone, and stored by Adidas.

AIT pitched Adidas management about its concept for what would eventually be named miCoach, and received the green light to begin development on the first miCoach project: the Samsung Adidas F110 miCoach mobile phone. Adidas management proposed a launch date of October 2007. Molecular expanded its team to include an interaction designer, project manager, numerous engineers, and quality assurance testers. AIT remained the same size until later in the development process.

Molecular directed the development of the web site based component of the project, now named miCoach, where users would interact with their data. The team conducted additional

user research to understand users' needs and experiences, including as described by the user experience leader:

We called it guerrilla interviews. We would go down to the Charles River (in Boston) where people run. We had a stack of cold bottled water. We just stopped and did a series of random interviews with runners, just to gather at the point in time when they're running, what are they feeling, what are they thinking, what's going on in their heads, what do they love most about it. – Molecular User Experience Leader

The Molecular team also focused on identifying what data miCoach would collect from users, building on AIT's guidance and the team's earlier efforts. Per the program manager for the project, the data collection requirements:

... were all based on what data did we need to help drive results? Our theory here was we should not collect or ask for anything that we weren't gonna use in some way. – Molecular Program Manager

The miCoach ecosystem would only collect data that would help fulfill users' need for fitness information, such as their heart rate, distance, and fitness goal. miCoach would analyze that data to personalize the user's recommended workouts.

The Molecular team interacted with Adidas' Germany-based legal team to understand user data-related security and privacy requirements in the European Union. The legal team advised that miCoach would need to collect a user's age and country so that the company could comply with country-specific regulations, including those regarding services for children. AIT determined that the F110 miCoach would not be for children, and screened for underage users through requesting their age. Per the Molecular program manager:

I worked with the legal and privacy teams that were in Adidas Corporate, to say here's the information we're collecting. What level of security and privacy do we need to establish, for this information that we're collecting?

That got into where can we store the data, in terms of where do the servers exist, can we load this information and make it available from the US, what kind of approvals do we need, and all that kinda stuff. We did have some legal compliance interaction, as well.

They were all based out of Germany because they have very strict privacy regulations over in Europe. I worked with those guys to figure what that was, and what we needed to do to mitigate it. – Molecular Program Manager

The Molecular technical team developed the system to store users' collected data, as well as the web site to convey this data to users. The team designed the system to support

AIT's earlier-described vision of an open platform. The technical team architected a system atop three levels of application programming interfaces. The Molecular account manager described these three levels:

We characterized three levels of APIs. One is APIs for internal development and the development partners, meaning I'm going to do some APIs so that tomorrow if we bring in a technology partner for something, it's easy to integrate with them. That's Level 1.

Level 2 is APIs for my business partners, which I will publish only to them. I decide (who a) business partner could be and I'll give them the keys so that they will technically be able to access my system via these APIs.

Level 3 level means they're open to the public, published, anybody can use them.
– Molecular Account Manager

AIT and Molecular jointly prioritized these levels' development by weighing their opportunities and costs, the technical team's knowledge and skills, and where they envisioned the project in the future. AIT and Molecular decided that at this stage the technical team would focus on the first and second levels due to their knowledge and skills, the project budget, and the vision for the project. The Molecular account manager described the decision:

Levels 1 and 2 are really about maturity of the team, best practices, and budget. You need the team who understands that, who is mature enough to do that, you need the product, you need to know a little bit what the product will do in order to build an API. Otherwise, you'll build an API for something that you don't know (how) it will evolve, so you waste time. The APIs come once you start to see where the product will go.

You need the right team with the right technology background, and you need the budget, because it requires time. That's for both 1 and 2. Level 3 requires a business strategy or a cultural decision. It's culture but it's business at the same time. The first two, they're not about culture; they're about the budget. – Molecular Account Manager

AIT and Molecular also managed the technical means for users to transfer their data from the heart rate monitor to the Samsung F110 mobile phone and then to the web site via user's desktop computer. The teams considered a number of options from outside companies, including the emerging ANT wireless data transfer protocol from Dynastream Innovations of Canada. The teams opted for Germany-based BM Innovations' BlueRobin protocol because Samsung had already adopted the technology. It is believed that AIT turned to existing

Adidas partner, watchmaker Fossil, to develop the sensors needed to collect heart rate and stride data.¹

AIT's interaction designer worked with designers at Samsung to design the F110 miCoach's mobile phone application, where users would interact with their collected fitness data. AIT also focused on the workouts and coaching information component of the F110 miCoach offering. While the team had experience using workouts, it did not have workout development experience. AIT turned to Athletes' Performance Institute, a training research center based at Arizona State University, to create a custom suite of workouts for F110 miCoach users.² These workouts would be personalized for users based on their collected heart rate data. For example, a workout would instruct a user to exercise for a period of time at one heart rate zone, then another period of time in a different heart rate zone.

AIT opted to embed Athletes' Performance Institute's analysis in the miCoach web site, rather than share the data with the company to analyze and return. While it is unclear why AIT designed the miCoach ecosystem this way, we can reasonably speculate that it is explained by similar reasons as AIT's concept phase decision to not use Microsoft's HealthVault to store user data. Perhaps AIT did not want to relinquish control over users' data, or was concerned that sharing the data could introduce a weak link in the ecosystem that jeopardized fulfilling users' needs.

AIT tested Athletes' Performance Institute's workouts themselves and with a group of private testers within Adidas. AIT also determined what audio coaching information would be spoken to users. An outside company recorded these phrases in multiple languages, and provided these recordings to Molecular for integration into the F110 miCoach.

The F110 MiCoach's planned release shifted from October 2006 to December 2007 and eventually March 2008. Team members attributed the delay to their inexperience creating such a hybrid mobile phone, sensors, and web site offering, as well as technical challenges and the complexities of coordinating development activities amongst AIT, Molecular, Athletes' Performance, Samsung, and BM Innovations.

AIT and Molecular team members' attention was also drawn to conceptualizing future miCoach-focused experiences, including a fitness watch, bracelet, and hub-type audio unit that could integrate with users' existing music devices. These concepts emerged from the teams and user studies.³ The teams also began working with Samsung on a second version of the F110 miCoach.

AIT led the development of the prototype bracelet and hub-type audio unit with its own engineers. The teams held discussions with a major third party watch manufacturer, which

¹According to Adidas miCoach Heart Rate Monitor User Guide. Fossil listed as the manufacturer responsible for the component.

²Adidas. adidas Launches Personal Training Platform With Real-Time Audible Coaching. January 7, 2010. <http://www.prnewswire.com/news-releases/adidas-launches-personal-training-platform-with-real-time-audible-coaching-80892972.html>

³The adidas method. The Economist. August 27, 2013. <http://www.economist.com/news/business/21584002-german-firms-unusual-approach-designing-its-products-adidas-method>

surfaced a number of potential user experience complications the team was experiencing working with Samsung on the F110. Per the Molecular interaction designer:

In particular, because Samsung had a lot of control over – it's their handset – so they have final say on what happens on these devices, what buttons are there. – Molecular Interaction Designer

Relying on an outside company for hardware development also impacted testing the F110 miCoach. Per the Molecular program manager:

When you are dependent on a third party, it can be a pain to get them to align to your schedules. We made it work with Samsung. Whereas, when you control the hardware component of it, then you're intrinsically interlinked between the two things. – Molecular Program Manager

The teams saw that closely tying miCoach to a mobile phone impacted their broader strategy of providing users with a lasting experience.

We realized that halfway through it wasn't the most sustainable way of keeping the product active, because it was dependent on the vagaries of launching a phone, which has a shelf life of – weeks, months, whatever. Especially one that's a specialty phone like this. – Molecular User Experience Leader

The teams realized that in order to have greater control over future miCoach devices, including the user experience and its specifications, they would need to develop these devices themselves. AIT promptly cancelled development of the second generation F110 miCoach.

I think at the end, the reason why Adidas decided to go with (its' own device) is because they wanted to have total ownership of the hardware and not have to worry about another group making decisions about what buttons are allowed to be there and what other hardware specifications needed to be there. – Molecular Interaction Designer

The decision to develop devices within the teams posed immediate challenges because team members did not have the skills required to design devices as technically complex as the F110 miCoach. The teams decided that future devices would focus on providing users with the simplest user experience that returned results, potentially reducing technical complexity.

AIT cancelled the watch concept, noting the challenges and complexities of creating such a device either with an outside manufacturer or by the team itself, and later the bracelet for unknown reasons. AIT instructed the Molecular team to focus on the hub-type audio unit, which became Pacer, while finishing the F110 miCoach.

Pacer was the answer to the limitations that came about as a result of the relationship and the limitations of the phone and technology and the reliance on Samsung. Pacer came about as an antidote to that. – Molecular User Experience Leader

AIT further refined the concept for the Pacer while the two teams finished the F110 miCoach development. AIT assigned the Pacer concept project the code name “Not A Phone” in reference to the concept being unlike and different from the F110 miCoach.

AIT envisioned the Pacer as a connected system of components and features delivering the user experience. Similar to the F110 miCoach, these components and features included the wireless heart rate monitor and stride sensors to collect users’ data, and the audio coaching information atop their music. Unlike the F110 miCoach, the device would integrate with users’ existing music players, such as their mobile phone or Apple iPod. In order to reduce the Pacer’s technical complexity it would not feature a visual, screen-based display interface.

Concept Stage Summary

Determinants of AIT’s response to its uncertainty during the concept stage include the team’s interpretations of the relative importance of user needs, its own expertise regarding fulfilling those user needs, and information economics concepts. The team’s interpretation of the relative importance of regulations were a minor determinant of the team’s response during the concept stage.

In 2006 AIT envisioned creating a new digital fitness product that would collect users’ personal data, analyze it, and return it to them as information. The team believed the product would fulfill users’ need for fitness-related information. AIT recognized that it was not expert to create the product itself, so it turned to outside companies for nearly all aspects of the product’s data ecosystem. With one of those companies AIT further identified that users needed personalized coaching information delivered in real-time via audio instructions, a feature that would differentiate the product in the market. Including this feature is supporting evidence for the team’s interpretation of the relative importance of information economics concept of differentiation as a determinant of the team’s response. AIT released this product in 2008 as the F110 miCoach mobile phone.

The data ecosystem for the F110 miCoach served as the foundation for the miCoach Pacer’s ecosystem. AIT’s interpretation of the relative importance of regulations was a minor determinant of the team’s response, as the team decided that given regulations the F110 miCoach would not collect children’s data. The miCoach Pacer ecosystem design inherited this decision.

As with the F110 miCoach, AIT again assessed that it was not expert providing key aspects of the data ecosystem, including the collection, wireless transfer, and analysis of users’ data. The designs diverged regarding the distribution of users’ data. In an effort to have greater control over the miCoach Pacer user experience, AIT decided to create its

own device to distribute data to users. This decision is supporting evidence for the team's interpretations of user needs as a determinant of the team's response to its uncertainty.

AIT's decision to fulfill users' need for actionable information led it to assess that it was not expert analyzing data to create such information, so it designed the ecosystem to feature analysis by the outside company Athletes' Performance Institute. This decision is evidence for the team's interpretation of the relative importance of its expertise as a determinant of its response, though in support of the cited user need as being the primary determinant. It is speculated that AIT opted to embed Athletes' Performance Institute's analysis within miCoach rather than share users' data with the company in order to better ensure the system fulfilled users' needs and that the outside company did not become a weak link in the ecosystem.

AIT would continue to rely on an outside company for its expertise distributing data to users via a web site, evidence for team expertise as a determinant of the design. The decision was a result of AIT deciding to support users' need for a web site to interact with their activity data.

During the concept stage AIT considered but not did implement two design characteristics that could have led to information economics having a more prominent role in determining the team's response. First, AIT considered storing users' data with Microsoft Health Vault, which could have fostered cross-side network effects for users and Microsoft. The team opted against the decision because it sought greater control over the user experience, supporting evidence for the team's interpretation the relative importance of user needs being a determinant of the team's response over its interpretation of the relative importance of information economics concepts.

Second, AIT intended to design the ecosystem to support the distribution of users' data to third party developers to create complementary services for users. AIT believed this would expand the size of the fitness device market, with Adidas having a prominent role in that market. AIT decided not to develop the needed application programming interfaces due to their insufficient knowledge and skills, budget, and unknown long term vision for the project. Deciding to create these interfaces would have supported the team's interpretation of the relative importance of information economics as a more prominent role determining their response.

AIT also considered designing the data ecosystem to allow users to download their collected data, however the concept stage design did not feature such functionality. It is unknown why this design was not implemented, though it can be reasonably speculated that lack of user need, resources, and budget played a role in the decision.

Summarizing the concept stage, case evidence supports that AIT's interpretation of the relative importance of user needs was the key determinant of the team's ecosystem design response. The team assessed that it did not have the expertise to fulfill those needs, and turned to outside companies for their expertise fulfilling those needs in the ecosystem. These decisions are supporting evidence for the team's interpretation of the relative importance of its expertise as a determinant of its response, though secondarily to the team's interpretation of the relative importance of user needs. AIT's interpretation of the relative importance

of information economics concept differentiation was a minor determinant of the team's response. AIT's earlier interpretation of the relative importance of regulations during the F110 miCoach's development was a minor determinant of the team's response.

6.3 Development Stage

In early 2008 and with the F110 miCoach nearing launch, the AIT and Molecular teams transitioned to developing the miCoach Pacer. Both teams grew in size, with AIT now composed of the team leader, two hardware engineers, mechanical engineer, algorithm engineer, user experience designer, and audio narration lead. During development, roles and responsibilities primarily fulfilled by Molecular, such as user experience and design, shifted to AIT.

Molecular's team grew to include additional web developers, quality assurance testers, and desktop software engineers. Molecular sought runners for these Pacer team positions, as such interest and experience was perceived as valuable to the development effort. As described by the Molecular account manager:

I think once we started to increase the team, I would say (running experience) was not a deciding factor, but it was one of the factors. One of the things you will ask, for example, in an interview for a new person to join the team, would be, 'Do you run?' Having somebody who would use the product was important. It was definitely a plus. – Molecular Account Manager

Molecular team leaders saw new hires as potential test users of the existing F110 miCoach and under-development Pacer. From the Molecular interaction designer:

One of my ways of ramping up when I first joined the project team (was using the F110 miCoach). I went out running with it so I could experience what it was like to use this. I'm not a runner, and that was an enlightening experience to get in the head of someone who exactly is the target here of a 'Couch to 5K' world.
– Molecular Interaction Designer

The team also engaged with users unaffiliated with the miCoach team, including friends and family members and other Molecular employees.

In March 2008 the Samsung Adidas F110 miCoach mobile phone was announced and released in Europe. The F110 miCoach included the mobile phone, heart rate monitor, stride sensor, and access to the miCoach.com web site to post and share running activities. The SIM-free, unlocked F110 miCoach cost approximately \$450.⁴

⁴Samsung F110 Adidas Review. GSM Arena. April 2, 2008. http://www.gsmarena.com/samsung_f110_adidas-review-235p6.php, based on exchange rates from XE. <http://www.xe.com/currencytables/?from=GBP&date=2008-04-01from=USD&amount=1&date=2008-04-01>

The release presented the Molecular team with an opportunity to expand their interaction with users, as up to this point the teams had access to a small quantity of near release-ready devices. At the April 2008 F110 miCoach product launch event the Molecular team gathered public user feedback. AIT's new user experience designer also led an external study with twelve miCoach F110 users in Germany and England. AIT recruited these public users by asking for volunteers on miCoach.com. Study participants included women and men with varying ages and exercise experience.

We got people who were passionate, early adopters of the product to agree to meet me and an assistant researcher. We met people where they lived and had them show us their workout kit and their miCoach.com interface. We talked to them about their experience so far. It was influential because of what we learned. It confirmed that we were on the right path, but that we had problems. – AIT User Experience Designer

The AIT user experience designer described these problems:

The phone and the data was so personal, giving you feedback about your own heart rate. If there were any problems with the sensor (data) collection, people really believed the data. Rather than attribute that to a problem with the sensor, they would say 'Oh, it's something with me!' We became a lot more mindful of how we might handle that in future products. We put a lot more into making sure the sensor setup was correct. – AIT User Experience Designer

Alongside gathering this user experience feedback, AIT and Molecular reflected on the data collection needs for the Pacer. Per the AIT leader:

We didn't look at the Pacer as a demographic modeling system. We literally wanted to make an honest relationship with the user where the brand, through miCoach, helped people get better, whether it was get healthier, or get in shape, or run a faster half marathon, or whatever their desire was. We only collected what we believed was valuable to the user. – AIT Leader

The Molecular team again interacted with AIT and Adidas' legal group in Europe to determine the impact of regulations on the miCoach Pacer's collection and use of users' data.

It basically always came through AIT in terms of requirements of what information we needed to interact with. Remember, this is a second-generation product, because the first one was the phone. They already ironed out the type of bio-data they were allowed to capture and retain from that first project. – Molecular Interaction Designer

While the F110 miCoach was released only in Europe, the miCoach Pacer would be available globally and thus need to comply with more and varied regulations. AIT and Adidas determined that the miCoach Pacer would adhere to the strictest regulatory requirements, which at the time arose from the European Union. AIT and Adidas legal communicated these regulatory impacts to the Molecular team. The regulations did not alter how and what data the miCoach Pacer collected and distributed, as it was similar to the already European Union regulatory compliant F110 miCoach.

AIT and Molecular addressed a key interaction design challenge for the Pacer. While the F110 miCoach featured a rich visual user interface on the mobile phone, the Pacer would not have such a display due to earlier-noted development complexity concerns. Molecular and AIT designed and internally evaluated various interaction styles, and chose one featuring small lights on the device.

AIT's engineers designed the hub-type audio connector component of the miCoach Pacer that would integrate with users' existing music players. AIT chose to outsource the manufacturing of the hub component to a consumer electronics contract manufacturer, which was standard practice throughout the company and not unique to AIT products or the miCoach Pacer.

AIT's engineers explored new ways to collect and transfer users' heart rate and cadence data and found it did not have the needed expertise. In order to fulfill this user need the team turned to a Canadian-based outside equipment manufacturer of fitness sensor technology for the heart rate and stride sensors. The company, Dynastream Innovations, was owned by Garmin, one of Adidas' competitors in the consumer fitness market. While these sensors were also used by Adidas' competitors, including Garmin, the AIT leader explained:

We believed the speed and distance was going to come a commodity just like heart rate and we didn't need to reinvent it. We should just buy the best one there was.

– AIT Leader

AIT also selected the company's sensors because they leveraged Dynastream's ANT+ wireless protocol to transfer data between the sensors and hub-type unit. The ANT+ protocol is a proprietary wireless data transfer standard collaboratively designed by a collection of stakeholders, particularly fitness device companies. These stakeholders make up the ANT+ Alliance, which is managed by Dynastream. Products that meet the ANT+ compliance terms feature a logo indicating their interoperability.

AIT considered using the BlueRobin wireless technology as in the F110 miCoach, however few other devices used BlueRobin. The team also considered Bluetooth, however the technology was power-intensive for a mobile device and the lower-energy Bluetooth LE was in the development stages. Dynastream's ANT+ overcame earlier shortcomings perceived by AIT, and was adopted by many of Adidas' competitors in the fitness electronics market. Adidas's decision to use ANT+ meant that that the Pacer's sensors would work with competitors' ANT+ compatible devices and that the Pacer was compatible with competitors' ANT+ sensors.

Throughout the miCoach Pacer's development the teams wanted to gather user feedback about the entire experience. The teams faced a challenge of gathering such feedback, as they needed a complete, functioning miCoach Pacer system. As described by the Molecular account manager, the teams faced a dilemma once the components were ready.

Molecular is a big believer of (user experience testing). Adidas also at that time had that culture. The challenge was finding the time to do that. It's the usual chicken and egg paradox. You need the product to execute real testing, but then, if you have the product, you probably also want to launch it, and you don't have enough time to go through more testing. – Molecular Account Manager

Early feedback came from AIT and Molecular employees themselves, who ran with the Pacer to gather their own experiences and to generate test data for analysis. AIT tested the Pacer with Adidas employees, who were generally experienced runners, at the company's private exercise facilities. Molecular team and non-team members included novice and experienced runners also used the Pacer.

Molecular team members used their runs to better understand how users would interact with the Pacer and miCoach, particularly regarding potentially complex and confusing aspects of the user experience. As noted by the Molecular program manager:

I was the super user of the device. I would run with it. I'd go, oh, you know what, this coaching zone thing doesn't make any sense because, when I do this, this concept breaks down. The more you use it, you start to see patterns in how that usage translates into things we need to fix in the product. – Molecular Program Manager

In July 2009 the teams transitioned to gathering feedback from external non-employee users. As noted by the AIT leader, these interactions introduced a valuable perspective to the miCoach Pacer project:

We have blinders on when we're developing products. We see what we want to see, and it's only when you put it in someone's hand who is a true user and not invested in the development that you get a fresh set of eyes. Choosing not to engage with a user is a missed opportunity. – AIT Leader

Molecular coordinated these interactions, which they called Total Experience Testing. As described by the Molecular user experience leader:

(Total Experience Testing) was trying to take somebody through the entire experience of using miCoach, from getting started all the way through to using it. All the way from getting started, to using the Pacer, going to the website, connecting it to the gear that you needed to use the experience, all of that. TET, as we called, Total Experience Testing, was hugely important. – Molecular User Experience Leader

Molecular saw this structured feedback as valuable for ongoing miCoach-related development efforts, and recognized that the Pacer's accelerated timeframe of January 2010 posed limitations on what could be done with the feedback.

In fall 2009 Molecular proposed a formal user evaluation study with users outside the company. While both companies supported user testing, Adidas was hesitant due to the added cost and time. Molecular convinced Adidas that the study could introduce new insights by further collecting the experiences of those outside the teams. As described by the interaction designer who helped run the study:

We recruited eight people to participate in a four week study. We brought them into our office over here in Boston. We had the box, where Pacer and the foot pod and the heart rate monitor, all of it was one bundle. We had the box in front of the user, and we had the unboxing experience as part of that initial intake for each of the eight participants.

(The users would) walk through the paper registration flow. That was just wire-frames that we hadn't built the registration flow yet. There was a quick start guide that was in the box, because it was supposed to help users figure out where to go, but it was a 25-page quick start guide. – Molecular Interaction Designer

The Molecular team observed these user-participants, fielding and posing questions about the unboxing the registration experience. Participants then left with the Pacer for a four-week diary study, where they would use the Pacer and share their experiences with other participants via a private web site forum. The Molecular team required participants to complete one task during the first week, the assessment run, where users would wear the heart rate monitor and stride sensor to collect their baseline fitness level. The study ended with an exit interview at the Molecular office, after which participants were able to keep the unreleased miCoach Pacer.

The external user study revealed a collection of insights about the user experience that when paired with the Molecular and AIT employees' experiences presented a number of potential changes to the miCoach Pacer. AIT decided which findings would be addressed, how, and when.

Users experienced challenges with the assessment run, particularly with regard to ensuring that the components communicated with one another and the their body to collect their data. Users were unfamiliar with how to correctly wear the heart rate monitor so that it would accurately collect data, which undermined the effectiveness of the coaching information. They were uncertain regarding how to respond to the real-time coaching audio instructions. In response to this feedback the team worked with Athletes' Performance Institute to create a pre-assessment run workout, during which the user would have the opportunity to test and learn the system and coaching information.

The study also revealed users supporting one another troubleshooting the miCoach Pacer's components and sharing running activities. Molecular characterized this user in-

teraction as much like a community, and proposed that miCoach offer user forums. AIT endorsed the idea and tasked Molecular with developing a solution for a later release. Molecular recommended that Adidas partner with Jive, a company providing such functionality as a service.

Molecular proposed developing a means for users to share their activities to social networking sites. The team believed such sharing would fulfill users' need for supporting one another, help those users stay motivated to exercise, and help miCoach grow. The team noted that sharing did not mean the ability to share data with other applications, such as those on mobile phones because such applications were not popular at the time. Nor did sharing mean users wanting access to their collected data, such as in a downloadable file. miCoach users did not widely request such data export functionality.

AIT endorsed the social network sharing idea and proposed that it develop its own social networking site for the miCoach runner community. The Molecular interaction designer described the ensuing discussion between the teams:

We had to fight to get (AIT) to understand that the worst thing they could do is build their own social network. If users already have all their networks... because Facebook has already been pretty popular at that point...we should hook into them. We should leverage users' existing social networks, not try to make them build a separate one in our system that's not connected to what they have outside. – Molecular Interaction Designer

AIT concurred and tasked Molecular with identifying ways for users to share their exercise activity with existing social networks. Two standards were emerging for third parties companies, such as Adidas, to interact with social networking sites. Per the Molecular interaction designer:

At the time, there wasn't a huge amount of technological openness. How to connect to social networks, at that time, we basically had Facebook and OpenID. There's only two. – Molecular Interaction Designer

Due to budget and time constraints, the teams had to decide which of the two miCoach would feature. They opted for Facebook because they perceived it was the dominant social networking site. Molecular used Facebook's Connect application programming interface to allow users to post their miCoach exercise activity to Facebook.

AIT and Molecular teams wrapped up final development for the miCoach Pacer in November 2009. Per the norm with AIT's projects, the Pacer was handed over to another team within Adidas for commercialization and release. This team was based at Adidas' headquarters in Germany. The transition to commercialization greatly expanded the number of people and teams with which Molecular and AIT interacted. Per the Molecular program manager:

We interacted with the brand teams in Europe, and the digital marketing teams in Europe, coming to the fray, once the commercialization happened. Then, we had these product managers who started to appear because this was now a viable program. We had the customer service guys I had to train. The packaging teams.

All of these other people started to emerge from the woodwork, which wasn't the fun building part. This is now commercialization. We need to make sure legal is okay with this, and the information security and IT team's okay with how we're hosting the servers. – Molecular Program Manager

The business unit named the device the miCoach Pacer, which up to this point was still referred to as “Not a Phone” by the AIT and Molecular teams. The business unit determined the Pacer's price and profit margin, which was not something the teams had considered.

When AIT first started the miCoach project, there was no initial target, in terms of ROI. They were a little innovation team, so their job is to innovate and come up with different things. Their job was not necessarily to come up with something that's gonna make money. – Molecular Interaction Designer

The whole entire paradigm started to shift, where (everyone) started thinking about, 'How can we actually monetize this? How can we make this bigger?' – Molecular Program Manager

AIT's deliberate focus on filling the figurative gap in the market where competitors were not offering products posed challenges for determining the miCoach Pacer's price. Per the Molecular interaction designer:

Pacer was trying to straddle this world between the super non-expert, 'Just track what I'm doing – Nike+' to this super detailed and really expensive watch. Nike+ was a much lower price point – \$25.00. It didn't coach you at all; it was just a little tracker. It was just a completely different market. But with the heart rate monitor involved, you were competing, actually, against the much more expensive Garmin watches. – Molecular Interaction Designer

The business unit priced the miCoach Pacer, including the hub-type audio unit, heart rate monitor, and stride sensor, at \$140.00, between the Nike and Garmin ends of the market. Per the Molecular interaction designer:

The main focus at that time was market share, how to get more people involved, how to get more people to see the Adidas brand. – Molecular Interaction Designer

Molecular and AIT's interactions with numerous Adidas teams in the United States and Europe helped ensure the miCoach Pacer was ready for release. Per the Molecular program manager, this diligence and attention to detail arose from Adidas' experience and philosophy:

Our mantra was everything should be buttoned up before this touched a customer. We would jump through hoops to make sure that that was the case. Adidas was used to building physical products, like shoes. You can't go yeah, let's just ship the minimal viable product, and then we'll add extra sole to it or something like that. That's not an option. You've gotta ship a complete product. There's certain minimal viable product conversations, but the minimal viable is pretty not minimal. It is fairly robust. – Molecular Program Manager

In late 2009 Adidas, AIT, and Molecular determined the miCoach Pacer was ready for release.

Development Stage Summary

AIT's interpretations of the relative importance of user needs and its expertise fulfilling those needs continue to be leading determinants of the team's response to its uncertainty during the development stage. The team's interpretations of the relative importance of information economics concepts and regulations do not appear to have been a determinant of the team's response.

The design reflects AIT's decision to replace two of the companies and their respective technologies responsible for the collection and wireless transfer of user data in the ecosystem. AIT again assessed that it was not expert to provide this aspect of the data ecosystem, and its selection of Dynastream's ANT+ sensors and wireless transfer technology fundamentally changed the design of the miCoach Pacer's data ecosystem.

As compared with the concept stage design of the miCoach Pacer's data ecosystem, the development stage design featured the ability to collect data from competitors' ANT+ compatible sensors. miCoach Pacer sensors could also collect data for competing ANT+ compatible fitness devices. The miCoach Pacer data ecosystem was designed to be compatible with other ANT+ data ecosystems, such as those offered by competitors. The concept stage data ecosystem design did not feature such compatibility.

The decision to adopt Dynastream's ANT+ technology furthered the AIT leader's concept stage objective of making miCoach an open platform. Fitness enthusiasts would be able to use their existing ANT+ compatible sensors to collect and transfer data to the miCoach Pacer's audio unit and miCoach web site. AIT's decision to adopt ANT+ did not alter the data analysis and distribution aspects of the data ecosystem design, as it did not result in users' ability to transfer their collected miCoach data to other systems.

The development stage data ecosystem design reflects AIT's decision to fulfill users' need to share their collected data with social networking sites. AIT's decision to support this user need changed the distribution aspect of the data ecosystem, including how and what was distributed and to whom. Users could choose to share their exercise activities, but not their raw collected data, with members of their social network on Facebook. The ecosystem design expanded to include Facebook and the social networking site's users, who may or may not also be miCoach users.

The decision furthered the leader's concept stage objective of making miCoach an open platform. The data ecosystem could now interact with other systems, albeit only unidirectionally from miCoach to Facebook. The decision resulted in AIT having less control over distribution in the data ecosystem, as now users controlled the distribution of their data outside the ecosystem. Prior to supporting this user need AIT controlled distribution in the data ecosystem via the Pacer device and miCoach.com.

In summary, AIT's interpretations of the relative importance of user needs and its expertise fulfilling those needs continued to be key determinants of the team's response regarding designing the data ecosystem during the development stage. These decisions impacted what and how data was collected, and what and how data was distributed and to whom in the ecosystem. AIT's interpretation of the relative importance of information economics concepts was a lesser determinant of the response, and its interpretation of the relative importance of regulations was not a determinant.

6.4 Release Stage

On January 10, 2010 Adidas announced the miCoach Pacer at the annual Consumer Electronics Show in Las Vegas, Nevada. The miCoach Pacer was available for \$139.99 at Adidas' company stores and web site. Competing fitness devices from Nike and Garmin ranged in price from \$29.99 to over \$349.99, respectively. The product's marketing materials, user manuals, and privacy policy depict the results of converting the team's vision into a consumer product.

The product press release provides an overview of the miCoach Pacer's features and functionality:

a small, lightweight device that delivers real-time audible coaching as a user exercises via headphones or combined with their own MP3 player. During a run, the miCoach Pacer verbally coaches the runner (i.e. speed up to green zone, slow down to blue zone, etc.) to ensure that they are staying within their targeted heart rate zone and keeps them running at the right personal level.

The press release described the associated miCoach.com:

At www.micoach.com, a user can create personalized training plans, set goals and proactively monitor and manage their progress over time. The miCoach platform includes six goal-based categories: Learn to Run; De-Stress; Be Fit; Lose Weight; Run a Race; and Finish Faster. Based on this personal information, miCoach creates an individualized training program that's tailored to a users heart rate zones and will help them achieve their fitness goals more efficiently than traditional exercise regimens. miCoach listens to a runner's heart to determine their personal training zone ranges, each represented by a distinct color for easy-to-understand and effective training - blue, green, yellow and red. miCoach helps

runners set goals and then reach them by monitoring their heart rate and telling them when to slow down or speed up to meet their personal goal.

The miCoach Pacer's product documentation provided users with further details of its features and functionality. The User Manual describes that it collects users' heart rate and stride rate (cadence) by the included chest strap-based heart rate monitor and foot pod sensor, respectively. When registering for miCoach.com the user is required to provide an email address, password, secret question, secret answer, screen name, country, date of birth, gender, height, and weight.⁵ By default this information, except for the user screen name, is not publicly displayed on miCoach.com.

The miCoach.com Privacy Policy details how the company uses this demographic data and fitness data collected from users:

Data collected from you are only used to make your training experience with miCoach as effective as possible and to create your training plans⁶

The company does not detail how it analyzes users' personal data and converts it into information, such as the number of calories burned, colored heart rate zone, distance, pace, or cadence. The company does not disclose its formula for calculating calories burned or its method for determining a user's heart rate zone color of blue, green, yellow, or red. The Quick Start Guide describes how:

miCoach personalizes a special set of heart rate zones to guide you through your workouts

The Guide discloses how these colored heart rates zones are determined for the user:

miCoach interprets data from your Assessment Workout to update your heart rate training zones

Adidas conveyed to users the accuracy, credibility, and limitations of the information it returned to users. First, the Quick Start Guide disclosed the accuracy of the foot pod sensor when calibrated or uncalibrated by the user (97% and 95%, respectively). It additionally acknowledged the provider of the sensor, Dynastream Technology, by name and logo, and indicated that the miCoach Pacer was ANT+ compliant. Users were provided with instructions for calibrating the foot pod sensor to their personal stride length, which varies amongst users and is often a function of user height and weight.

Second, the company disclosed that the information provided by the miCoach Pacer was not a substitute for medical advice, as it was not an approved medical device. The User

⁵Legal & Privacy Terms and Warranty Information. Adidas. http://web.archive.org/web/20110924071554/http://community-micoach.adidas.com/docs/DOC-LEGAL-ENG_116

⁶Adidas miCoach Privacy Policy - post-launch September 2011. http://web.archive.org/web/20110924071554/http://community-micoach.adidas.com/docs/DOC-LEGAL-ENG_116

Guide specifically noted the credibility and limitations of the personalized workouts and audio feedback provider to users:

The advice and workout plans prepared by qualified, responsible coaches are based on the latest scientific and technical research. However, they do not constitute a medical consultation and cannot replace medical advice.

Users could choose to hear their audio feedback in one of eleven languages, in either male and female genders. The languages included American and British English, Cantonese and Mandarin Chinese, French, German, Japanese, Korean, Russian, Portuguese, and Spanish.

Users were presented with several ways to enact control over the data collected by their miCoach Pacer and miCoach.com, including changing and deleting data, and specifying if and how it is shared with others. These control privileges correspond to European Union regulations at the time regarding the collection and use of personal data. The miCoach.com Privacy Policy informed users:

You can access and change your personal data at any time. You can object to the continued use of your data at any time. In this case we will delete your personal data.

The Privacy Policy and User Guide detail how collected data is shared with others, including third parties, fellow miCoach.com users, and the public. With regard to third parties, Adidas pledged in its Privacy Policy:

Our guidelines require to treat your data as strictly confidential. We will not share them with third parties.

The User Guide states that the company will share user data with third parties, but only with users' consent or when those third parties provide services that support miCoach.com:

Adidas does not disclose your data to third parties without your prior agreement. Adidas works with support companies who create, maintain, administer and host our miCoach websites on their servers, answer your question and help with your technical problems. Those service companies are contractually required to use any data they can access only for the above purposes and to never disclose these data to third parties.

Adidas provided users with multiple ways to share information in the form of workout results with others on the Internet. Workout results could include such information as distance ran and calories burned. Adidas cautioned users in the User Guide:

All data and information uploaded to the internet by the customer in connection with the usage of miCoach, may be visible to and usable by the public. Third parties might take notice, share, publish, copy, transmit or use the uploaded data and information otherwise.

Coupled with this warning, the company declared:

Adidas is not liable under any circumstances for the data and information uploaded. The customer grants access to his/her data at his/her own risk. Adidas assumes no responsibility for the loss, misuse or any uncontrolled circulation of the uploaded data.

The Privacy Policy further detailed the four ways miCoach users could share their workout results with others on the Internet. First, by emailing those results to friends via miCoach.com. Second, publishing results on a public miCoach.com page. Third, by sending those results to Facebook for publishing in your profile. Fourth, by emailing a link to your Facebook friends to see your results on a public miCoach.com page. The policy notes the risks of the first method:

Please understand that sending an e-mail is like sending a postcard. On the way to its destination, anyone with access to it can read its contents. The data are sent unencrypted.

As with personal data collected by miCoach, users held control over the workout results information they shared with users, including having:

the right to remove the publicly visible page containing (their) workout results from the miCoach website at any time.

The Privacy Policy concluded with the succinct statement for users regarding control their information:

The decision as to whether you want to share your workout experiences with others is yours and yours alone.

While miCoach users could control the collection and sharing of their personal data, that control did not extend to access to the data itself. Users could not readily download their collected data, such as in a comma-separated value (CSV) or Excel spreadsheet from miCoach. The artifacts inform users to contact Adidas support for a file containing their data, which fulfilled European Union regulations regarding consumers' access to their collected data.

Release Stage Summary

The Adidas miCoach Pacer's public artifacts illustrate multiple aspects of its data ecosystem's design, revealing many but not all details of how and what data is collected and distributed in and by the ecosystem. The artifacts support AIT's decision to fulfill users' need for personalized real-time coaching information, but do not indicate that AIT relied on

an outside company for their expertise fulfilling this product-differentiating user need. Given the miCoach Pacer's price in the middle of the market, it does not appear that AIT pursued a penetration pricing strategy. This differentiating feature and mid-market price are minor supporting and non-supporting evidence, respectively, for the team's interpretation of the relative importance of information economics being a determinant of the team's response.

With regard to user needs, the artifacts disclose what and how the miCoach Pacer collects data from multiple sensors, including heart rate and stride sensors, and other personal data from users. Multiple artifacts describe how the miCoach Pacer provides users with new information in the form of real-time audio coaching, as well as familiar information such as calories.

The artifacts reveal Dynastream as the provider of the ANT+ technology collecting and wirelessly transferring users' data, but do not indicate that AIT relied on Dynastream for its expertise. The artifacts highlight the data ecosystem's compatibility with other ANT+ systems. Athletes' Performance Institute is not referenced in the artifacts, or the role of an outside company analyzing users' data to personalize their coaching information. The artifacts do not disclose Molecular's name or role developing and providing the miCoach component of distributing data in the ecosystem. Facebook's role in the data ecosystem is disclosed, as well as users' control over whether their information is distributed to the social networking site. It is unknown why AIT decided not to disclose Athletes' Performance Institute and Molecular's names or roles in the data ecosystem.

The miCoach Pacer's compliance with European Union regulations is not stated in the artifacts. Per the artifacts and as regulations require, users have control over and access to their collected data, and Adidas will not share the data with other companies without prior agreement. These statements offer insights into the data ecosystem's distribution design. Since Adidas did not reveal Athletes' Performance Institute's name nor did it ask for users' permission to share their data with the company, we can reasonably infer that the ecosystem does not share users' data with the company.

Evidence in the release stage of the case supports that AIT's interpretation of the relative importance of user needs was the key determinant of the team's response to its uncertainty regarding designing the data ecosystem. The public artifacts support that AIT's interpretations of the relative importance of information economics concepts and its expertise were minor determinants. Evidence in the release stage does not support that the product team's interpretation of the relative importance of regulations was a determinant of the team's response.

6.5 Summary

AIT's interpretation of the relative importance of user needs was the key determinant of the team's response to its uncertainty regarding designing the miCoach Pacer's data ecosystem. Figure ?? on page ?? depicts the data ecosystem design. The team's assessment of its expertise fulfilling those user needs led it to turn to outside companies to fulfill those needs,

providing supporting evidence for the team's interpretation of its expertise as a determinant of its response. One of those needs differentiated the miCoach Pacer in the market, supporting the team's interpretation of the relative importance of information economics as a minor determinant of its response. Evidence supports that AIT modified the data ecosystem for the miCoach Pacer predecessor, the F110 miCoach, to comply with regulations regarding collecting children's data. The miCoach Pacer data ecosystem inherited this design characteristic from the F110 miCoach.

The design of the miCoach Pacer's data ecosystem is a reflection of AIT's interpretations of the relative importance of user needs and its expertise fulfilling those user needs. AIT's decision to fulfill users' need for real-time coaching information led it to turn to the expertise of Athletes' Performance Institute. Fulfilling this need differentiated the miCoach Pacer in the market. With those decisions AIT relinquished some control over what and how data was collected, and what data was distributed in the ecosystem.

AIT's decision to fulfill a second key user need further altered the design of the data ecosystem. Users sought the ability to share their activities with friends on the social networking site Facebook. Fulfilling this need meant that Facebook became part of how the data ecosystem distributed data. Up to that point AIT controlled how data in the ecosystem was distributed via miCoach.com and the device. AIT's decision to support users' need to share summary activity data with Facebook enabled the flow of data out of the ecosystem.

AIT's lack of expertise collecting and wirelessly transferring data led it to adopt ANT+, making the ecosystem compatible with competing systems. The ecosystem could then figuratively tap those competing systems for data, broadening the sources of user data flowing into the ecosystem.

AIT considered two additional decisions that would have further altered the distribution of users' data in the data ecosystem. AIT explored designing the data ecosystem to share users' data with third party developers, who would create complementary services for users. AIT believed these services would help expand the fitness device market. Such services could foster cross-side network effects for users and those third party developers, potentially supporting evidence for the team's interpretation of the information economics concept network effects as a determinant of the ecosystem design. AIT opted not to alter the design due to their insufficient knowledge and skills, budget, and unknown long term vision for the project. AIT also explored allowing users to download their data, but for unknown reasons opted against the design. These decisions would have expanded how data was distributed in the ecosystem, as well as to whom that data could be distributed. If AIT had altered the design to include third party developers, the team's interpretation of the relative importance of information economics concepts would have been a larger determinant of the team's response.

In summary, AIT's interpretation of the relative importance of user needs was the key determinant of the team's response to its uncertainty regarding designing the miCoach Pacer's data ecosystem, followed by the team's interpretation of the relative importance of its expertise. The team's interpretation of the relative importance of information economics concepts was a minor determinant of its response. Evidence supports that AIT's interpretation of the

relative importance of regulations was least determinant of its response.

Chapter 7

Identifying the Variance

7.1 Introduction

As noted in Chapter 1: Introduction, product teams are uncertain regarding designing the data ecosystems for their instrumented fitness experiences. That uncertainty stems from multiple related uncertainties regarding the new forms of personal data that can be collected, the reliable collection and analysis of that data, the usefulness of information returned to users, and social acceptance of such data collection and use. Product teams are uncertain regarding the forces shaping what and how physiological data is collected and distributed within an instrumented fitness experience data ecosystem. Given this uncertainty, different product teams have what are in effect different theories regarding where value will be created in and by their data ecosystems and the strategies for creating that value.

The Suunto product team believed its ecosystem could best create value through designing it to focus on users and enabling the flow of data and information from and to those users. The strategy for doing so included designing the ecosystem to collect users' existing fitness activity data and distribute multiple forms of exclusive information. This information included users' activity-related environmental information, such as altitude and ascent rate. EPOC and training effect conveyed the impact of users' training activities on their overall fitness. The team designed the ecosystem to allow users to download their collected data for their own analysis and for sharing with coaches and friends. In order to fulfill this strategy the team licensed needed ecosystem components from Dynastream International and Firstbeat Technologies, which created value for these two companies.

The Garmin product team's response conveys their belief that the best way to create value was to design the ecosystem to focus on users and companies who could offer those users complementary services. The team's ecosystem design collected users' existing fitness activity and allowed users to export their collected data. An application programming interface and software development kit allowed other companies to create complementary services, such as web sites and desktop software, for users who consented to sharing their data with those companies. The team these services would spur the creation of additional value

for users and Garmin itself. As part of fulfilling this strategy Garmin acquired providers of two ecosystem components, MotionBased Technologies and Dynastream International. With these acquisitions Garmin supplied all of its needed ecosystem components itself.

The Adidas product team believed its design could best create value through focusing on users and controlling the creation of value for those users. The team designed its ecosystem to distribute exclusive personalized, audio-based coaching instructions to users in real-time while exercising. The team considered but did not pursue a design that would have allowed companies to create complementary services with users' data. In order to fulfill this strategy the team licensed needed ecosystem components from Dynastream International and Athletes' Performance Institute, creating value for these two companies.

This chapter examines the teams' responses to their uncertainty, specifically their decisions regarding what and how data was collected and analyzed in the ecosystems, and what and how data and information was distributed and to whom. These decisions impacted how value was created in the ecosystems and for whom, as well as the relative amount of value that could be created in and by the ecosystems.

Understanding product teams' varying responses to this uncertainty is critical for assessing what explains those responses, the goal of this dissertation. Chapter 2: Guiding Concepts presented four candidate explanations for teams' responses to their uncertainty: teams' interpretations of the relative importance of user needs, information economics concepts, regulations, and their own expertise. These candidate explanations are assessed in Chapter 8: Explaining the Variance.

7.2 Analysis Framework

The comparison of product teams' responses examines two key aspects of each team's response. First, their instrumented fitness experience's data ecosystem design. Recall from Chapter 1: Introduction that an instrumented fitness experience's data ecosystem design is the arrangement of interactions and processes that collect, analyze, and distribute users' data and information. The second aspect is the value created by that design, including the forms of value, how value was created and for whom, as well as the relative amount of value created in and by the design. Given the radical uncertainty under which teams operated, this analysis defines value in an encompassing sense as gains, usefulness, opportunities, and revenue. Value is not considered solely in an economic sense, as such a narrow definition would be more apt for analyzing teams' responses to their uncertainty regarding designing business models for their instrumented fitness experiences. This dissertation examines the broader concept of teams responses' to their uncertainty regarding designing their data ecosystems. Comparing product teams' responses contributes to understanding the candidate explanations for those responses, which are assessed in Chapter 8: Explaining the Variance.

The ecosystem design aspect of the response comparison draws on Figure ?? Instrumented Fitness Experience Data Ecosystem, which was introduced in Chapter 1: Introduction on

page ??). An instrumented fitness experience data ecosystem features the following components: what and how data is collected and analyzed and by whom, and what and how data and information is distributed and to whom. The figure’s collection, analysis, and distribution components serve as a framework for comparing the three ecosystem designs.

The value creation aspect of the response comparison identifies the myriad forms of value created in the ecosystem designs, to whom that value was allocated, and the relative quantity of value created. For example, an ecosystem design may create value for users by returning to them information not found in competing instrumented fitness experiences’ ecosystem designs. The design returning this exclusive information would create comparably more value than designs without this information.

While this comparison makes no effort to numerically quantify the value created by the data ecosystems, it identifies and compares how the designs created more or less value relative to each another. At this point in the emergence of instrumented fitness experiences it is critical to understand how and where value is created and for whom in these data ecosystems, as well as the relative amount. Future researchers may use this dissertation’s examination of these value creation dynamics to inform their efforts to numerically quantify the myriad forms of created value.

7.3 Collection

Product teams responded in different ways to their uncertainty regarding designing the collection aspect of their data ecosystems. As depicted in Table ?? Data Collection in Case Data Ecosystem Designs on page ??, the teams designed their ecosystems to collect varying data, including personal, physiological, and environmental data. The teams’ designs further varied regarding how that data was collected and by whom. This variance created value in different ways, for different ecosystem participants, and at different scales.

Table 7.1: Data Collection in Case Data Ecosystem Designs

Aspect	Suunto T6	Garmin Forerunner 50	Adidas miCoach Pacer
What: Physiological	heart rate variability	heart rate distance cadence	heart rate distance cadence
How: Physiological	Suunto-designed heart rate monitor strap sensor to Dynastream-designed ANT wireless protocol to Suunto-designed watch	Dynastream-designed heart rate monitor strap and foot pod sensors to Dynastream-designed ANT+ wireless protocol to Dynastream-designed watch	Dynastream-designed heart rate monitor strap and foot pod sensors to Dynastream-designed ANT+ wireless protocol
What: Personal	weight height gender year of birth country	weight height	weight height gender date of birth country

Table 7.1: Data Collection in Case Data Ecosystem

Aspect	Suunto T6	Garmin Forerunner 50	Adidas miCoach Pacer
	first name last name email address address city state postal code language favorite sport age smoking status activity level maximum heart rate		
How: Personal	user enters via Suunto Training Manager software and suunto-sports.com	user enters via Garmin Training Center software and Garmin Connect site	user enters via miCoach.com
What: Non-Personal	altitude barometric pressure compass direction		
How: Non-Personal	Suunto-designed sensors on T6 watch		
What: Existing	user fitness activities	user fitness activities	
How: Existing	user imports in CSV format	user imports in CSV format	
How: Transfer	via USB computer interface cable	wirelessly via Dynastream ANT+ to USB stick	via USB computer interface cable
What: Format	SDF	FIT	FIT

The Suunto T6 product team responded to its uncertainty by collecting physiological data in the form of heart rate variability. Collecting this data created value for users, as the ecosystem analyzed and converted this data into two new forms of actionable fitness information: training effect and EPOC. The Suunto team's decision to collect heart rate variability data allowed its ecosystem design to create comparably more value than the Garmin Forerunner 50 and Adidas miCoach Pacer data ecosystems. Neither the Garmin or Adidas ecosystems collected heart rate variability, rather only heart rate in the form of beats per minute. It is unknown from the case evidence why the teams opted to collect heart rate instead of heart rate variability, though we can reasonably speculate that the decisions related in some part to their uncertainty regarding collecting and analyzing heart rate variability. As noted in the Suunto case, heart rate data could not be analyzed to create the same information as analyzing heart rate variability data. Suunto's collected heart rate variability data could be converted into heart rate data, allowing it to return the same heart rate-related information to users as the Garmin and Adidas ecosystems. Suunto's decision to

collect heart rate variability data resulted in its ecosystem being able to create comparably more value because the other ecosystems did not collect such data.

The Garmin and Adidas product teams' decisions to collect users' distance and cadence data allowed them to create value not found in the Suunto ecosystem design. The Garmin and Adidas ecosystems created value with this data by analyzing it and returning it to users. Suunto ecosystem could not create this value for users when the T6 was released, as it did not feature the foot pod sensor needed to collect this data. Once the Suunto foot pod sensor was released all three ecosystems created similar cadence and distance-related value for users.

The product teams' decisions regarding collecting users' physiological data created and allocated value in different ways. Suunto utilized its own heart rate sensor, Garmin turned to its subsidiary Dynastream, and Adidas also turned to Dynastream. Adidas' decision allocated value in its ecosystem to Dynastream, while Suunto and Garmin allocated this value to themselves. For Adidas this value took the form of monetary payment, as the company paid a fee to Dynastream for the heart rate sensor. The Adidas ecosystem design also allocated value to Dynastream for its foot pod sensor. At release the Suunto ecosystem did not feature such a sensor, and Garmin again turned to its subsidiary Dynastream for its needed sensor.

All three product teams decided to feature Dynastream's wireless protocols to collect and transfer users' physiological data. This shared design characteristic created value for users, Dynastream, and the designs' respective companies. That created value took varying forms at vary scales. Garmin and Adidas' decision to use ANT+ also allocated value to outside companies with ANT+ compatible technologies.

Suunto's decision to use ANT created multiple forms of value for Dynastream, as well as value for Suunto and T6 users. Suunto licensed the ANT technology from Dynastream, and though not confirmed in the case evidence, likely paid a licensing fee to Dynastream. The product team's decision to use Dynastream's technology also created non-monetary value for Dynastream. The Suunto T6 was amongst the first consumer products to adopt ANT technology. Dynastream could leverage the product team's ecosystem design decision as an early endorsement for its ANT technology, potentially leading to Dynastream forging additional licensing arrangements with other companies. The decision to collect data with ANT technology also created value for users, who could use other ANT-compatible sensors to collect their data. For example, a Suunto T6 user could use their included heart rate monitor sensor with other future Suunto ANT-compatible devices. This compatibility created potential value for Suunto, as T6 users may purchase future Suunto devices and use their existing T6 sensors with those devices. Since ANT had company-specific compatibility, T6 users could not use their T6 sensors with competitors' ANT-based instrumented fitness experiences.

Garmin and Adidas responded to their uncertainty by using Dynastream's ANT+ sensors to wirelessly collect and transfer users' data. Dynastream's ANT+ sensors were not available during the Suunto team's development efforts. The decision to use ANT+ sensors similarly created value for users, Dynastream, and themselves, as well companies providing competing ANT+ compatible instrumented fitness experiences. The decision created value for users in

that they could leverage their existing ANT+ compatible sensors to collect data for their Garmin or Adidas instrumented fitness experience. Such user behavior also created value for Garmin and Adidas, as it expanded their ecosystems' ability to collect physiological data that would then be analyzed and distributed to users in their own ecosystems. This compatibility created value for users, as they could use their Garmin and Adidas ANT+ sensors with future ANT+ instrumented fitness experiences, whether offered by Garmin, Adidas, or competitors. This compatibility also created value for providers of those competing instrumented fitness experiences, as it eased and expanded their ability to collect data for their experiences.

Similar to the Suunto design, Garmin and Adidas' decisions to use ANT+ created value for Dynastream. Though not confirmed in the Garmin case evidence, Dynastream likely received monetary compensation for licensing ANT+ and supplying the body-worn sensors in the data ecosystem. Since Garmin had acquired Dynastream as part of creating the data ecosystem, this monetary value likely flowed back to Garmin. Adidas paid a fee to Dynastream for its foot pod sensor, and though not confirmed in the case evidence, likely paid a licensing fee for the right to use Dynastream's ANT+ technology. Since Dynastream at this point in time was a subsidiary of Garmin, we could reasonably speculate that all or a portion of the fees Adidas paid to Dynastream went to its competitor, Garmin.

Comparing the amount of value created by ANT and ANT+ in the ecosystems, it seems reasonable to speculate that the broader compatibility of ANT+ would correspond with relatively greater value creation. The value created by Garmin and Adidas' decision to use ANT+ in their ecosystems was larger than the value created by Suunto's decision to use ANT. That broader compatibility and value generation came with the tradeoff that the ecosystems' ANT+ sensors could be used to create value in competing ANT+ compatible instrumented fitness experiences.

The product teams responded to their uncertainty by collecting varying breadths of users' other personal data. While all three ecosystems collected users' weight and gender, the Suunto team decided to collect much more additional personal data than the other ecosystems. This additional personal data presented Suunto with the opportunity to create more value than those ecosystems that did not collect this data. Though unclear from the case evidence, Suunto may have collected users' self-reported fitness level in order to return value to users in the form of more accurate fitness information. Adidas created value by collecting users' fitness goal and using that data to recommend workouts to those users. Suunto and Garmin did not collect this data.

All three data ecosystem designs collected this other personal data via their web site component, and the Suunto and Garmin ecosystems also collected this data via their desktop software. The Adidas ecosystem did not feature desktop software. Collecting this data via multiple ecosystem components does not appear to have impacted the creation of value in the Suunto and Garmin ecosystems, or the distribution of that value. As discussed later in this chapter, these desktop software and web site components impacted how value was created through distributing users' data and information.

The Suunto team further responded to its uncertainty by designing its ecosystem to collect environmental data. The T6 watch featured sensors that collected users' altitude,

as well as the barometric pressure and their compass direction. Since Suunto designed the sensors to collect this data this value was not allocated in the ecosystem to another company. Suunto's collection of this environmental data allowed it to create value exclusive to its ecosystem, since Garmin and Adidas did not collect this data in their ecosystems. Similar to Suunto's collection of heart rate variability, collecting this data allowed the ecosystem to create comparably more value than those ecosystems that did not collect such data.

Suunto and Garmin responded to their uncertainty by designing their ecosystems to collect users' existing activity data, which created value for users as well as the respective companies. For users that value took the form of being able to import their existing activity data, such as that they had logged themselves, expanding the breadth of data users could analyze and interact with in the ecosystems. The design characteristic also created value by lowering a user's switching costs to adopt either the Suunto or Garmin instrumented fitness experience, as long as the user's existing fitness system allowed them to export their collected activity data. Both companies' decision to use the non-proprietary CSV (comma-separated value) format for importing data eased users' ability to transfer data into the ecosystems. These users did not have to wait and collect new data before the Suunto and Garmin ecosystems returned value in the form of fitness information and means to interact with that information. Users could import their existing data and in effect bootstrap the creation of value for themselves in the ecosystems.

This data import characteristic created value for Suunto and Garmin. Lowering users' switching costs created value by potentially making the instrumented fitness experiences more appealing to new users who had amassed activity data in competing systems. Much like ANT+, the design also created value by expanding the amount of data that could be analyzed and returned to users as information. This value creation for users, Suunto, and Garmin, was exclusive to their ecosystem designs, since Adidas' ecosystem did not feature the ability to collect users' existing activity data. Given this characteristic, the Suunto and Garmin ecosystems could create comparably much more value for users and the respective companies than the Adidas ecosystem design.

Garmin's decision to wirelessly transfer data from the Forerunner 50 watch to the user's desktop computer via ANT+ created value for users, as it potentially contributed to a better user experience than the other ecosystem designs. Both Suunto and Adidas required that users physically connect their T6 watch or Pacer device to their computer to initiate data transfer, while Garmin only required users to place their Forerunner 50 near their computer for such transfer. The Garmin ecosystem wirelessly transferred users' data with Dynastream's ANT+ technology. Though unclear from the case evidence, Garmin likely licensed ANT+ from Dynastream for a fee. As noted earlier, since Dynastream was owned by Garmin fees may not have actually been exchanged. Garmin's design decision created comparably more value, particularly for users, than the Suunto and Adidas ecosystem designs.

The data ecosystems stored and transferred users' collected activity data in either of two formats. Suunto introduced its SDF (Suunto Data Format) file format with the T6, which was a CSV-based file format that users could edit and view with commonplace desktop computer spreadsheet software. This design decision created value for users through easing

their ability to view and edit their collected data. The Garmin and Adidas ecosystems utilized Dynastream's FIT format, which Dynastream developed for and was required by its ANT+ technology. Users could not view or edit these FIT files without additional desktop software, which was not provided to users. Unlike Suunto and its' SDF, it is less clear if and how FIT created value for Garmin and Adidas users. Given this evidence it is reasonable to speculate that Suunto SDF created comparatively more value for users than Garmin and Adidas' FIT.

In summary, the product teams responded in similar and different ways to their uncertainty regarding designing the data collection aspects of data ecosystems. Suunto's decision to collect users' heart rate variability data presented the opportunity for its ecosystem to create comparably more value than those ecosystems that only collected heart rate data. Suunto and Garmin's decisions to design their ecosystems to collect users' existing activity data via import allowed those ecosystems to create relatively more value than Adidas' ecosystem, which did not have such functionality. This design decision lowered users' switching costs and allowed users to more quickly interact with their data in the ecosystem. On the other hand Adidas users could only interact with data collected via the miCoach Pacer, either by its included sensors or other ANT+ compatible sensors.

All three product teams responded to their uncertainty by adopting wireless collection and transfer technologies that broadened their ecosystems' data collection aspects' compatibility. The teams used Dynastream's wireless technologies to collect and transfer users' data, however the company's ANT and ANT+ technologies created value in different ways and at different magnitudes. This value creation hinged on compatibility. Suunto's decision to use ANT allowed its users to create value in the ecosystem by using other ANT-compatible sensors offered by Suunto. This created value was comparably less than that created by Garmin and Adidas' use of ANT+, as ANT+ was compatible with the companies' and competitors' sensors. Garmin and Adidas' decision to use ANT+ posed tradeoffs, as the companies' sensors could also be used to create value in competitors' ANT+ compatible instrumented fitness experiences.

The teams' responses created varying relative quantities of value in their ecosystems. With regard to what data was collected, it appears Suunto's decision to collect more and exclusive data presented it with the opportunity to create more value than the ecosystems that did not collect such data. Suunto and Garmin's decisions to allow users to import their existing data allowed the ecosystems to create more value than Adidas' design, which did not feature such functionality. Both Suunto and Garmin's ecosystems could create more value with users' imported data. Lastly, Suunto's decision to use ANT allowed it to create more value within its own ecosystem, while Garmin and Adidas' decision to use ANT+ allowed the designs to create value within and outside their own ecosystems. It would be reasonable to speculate that this latter decision created more value than Suunto's decision.

7.4 Analysis

The product teams responded in either of two ways regarding their uncertainty designing the analysis aspects of their data ecosystems. As depicted in Table ?? Data Analysis in Case Data Ecosystem Designs on page ??, Suunto and Adidas designed their ecosystems to feature outside companies' analysis, while Garmin opted to analyze collected data itself. These strategies created value in the ecosystems in different ways.

Table 7.2: Data Analysis in Case Data Ecosystem Designs

Aspect	Suunto T6	Garmin Forerunner 50	Adidas miCoach Pacer
Who	Nordic Semiconductor Firstbeat Technologies	Garmin	Athletes' Performance Institute
Where	watch and within Training Manager software and su- untosports.com	within Training Center software	within miCoach web site

The Suunto and Adidas ecosystems are noted by the role of outside companies analyzing users' data. Suunto turned to Firstbeat Technologies to convert users' heart rate variability data into training effect and EPOC. Adidas used Athletes' Performance Institute's analysis to inform the real-time audio coaching instructions provided to users. Suunto used Nordic Semiconductor's chip within its T6 watch to analyze users' data, such as heart rate and heart rate zone. It is not known how Garmin and Adidas analyzed users' data on their respective devices.

Suunto and Adidas' decisions allocated value in their ecosystems in the form of monetary compensation to these outside companies. Suunto's disclosure of Firstbeat Technologies and Nordic Semiconductor in the T6's public artifacts presented the two companies with additional value. Suunto's disclosure served as an early endorsement for the companies' data analysis and semiconductor technology, potentially leading to additional licensing arrangements for the companies. Since the ecosystems were not designed to allow Firstbeat Technologies, Nordic Semiconductor, or Athletes' Performance Institute to access users' data, the companies could not create new value for themselves with users' data. Garmin's decision to analyze users' data itself meant that the value created through analyzing users' data was allocated to users and the company itself, rather than an outside company.

Adidas' ecosystem design allowed it to create additional value with Athletes' Performance Institute analysis. Adidas could view and modify the company's analysis to improve the instructions it provided to users. In contrast Suunto's ecosystem featured a black box arrangement, where Suunto did not have visibility into Firstbeat Technologies' analysis. With such an ecosystem design Suunto could not create additional value with the analysis.

Suunto and Adidas' response to the uncertainty of designing the analysis aspects of their data ecosystems allocated value to outside companies. It is unclear if that value was more or less than the value Garmin allocated to itself through analyzing data itself. Adidas' response featured its ability to modify Athletes' Performance Institute's analysis, which allowed its design to create comparably more value than Suunto's black box analysis design.

7.5 Distribution

Each product team responded in a unique way to their uncertainty regarding designing the distribution aspect of their data ecosystems. As depicted in Table ??: Data and Information Distribution in Case Data Ecosystem Designs on page ??, the teams designed the distribution aspects of their ecosystems to either enable users to create additional value, spur valuation creation by outside companies, or limit additional value creation. This design variance created value in the ecosystems at different scales.

Table 7.3: Data and Information Distribution in Case Data Ecosystem Designs

Aspect	Suunto T6	Garmin Forerunner 50	Adidas miCoach Pacer
What: Physiological	EPOC training effect heart rate heart rate zone calories oxygen consumption ventilation respiratory rate VO ₂ max number of laps average heart rate minimum heart rate maximum heart rate heart rate time in zone heart rate time over zone heart rate time under zone total duration	total run time total distance total steps heart rate zone calories heart rate time in zone average heart rate average lap speed	elapsed time pace heart rate heart rate zone calories distance cadence
What: Other	altitude barometric pressure ascent rate descent rate cumulative ascent cumulative descent temperature highest altitude highest altitude time lowest altitude lowest altitude time		
How: Device	to user via T6 watch	to user via Forerunner 50 watch	to user via audio via Pacer
How: Web Site	to user via suuntoports.com	to user via Garmin Connect	to user via miCoach.com
How: Desktop Software	to user via Suunto Training Manager	to user via Garmin Training Center	

Table 7.3: Data and Information Distribution in Case Data Ecosystem Designs

Aspect	Suunto T6	Garmin Forerunner 50	Adidas miCoach Pacer
How: Export	to user via export as SDF via suunto-sports.com	to user via export as CSV via Garmin Connect	to user via email on user request
How: Other Users	to other suunto-sports.com users	to other Connect users	activity data via public miCoach activity page
How: Non-Users	user emails activity data to non-users	user emails activity data to non-users	user posts miCoach activity data to their Facebook profile page user emails Facebook user a link to public miCoach activity data page user sends email containing single miCoach activity data
What: Other Companies	will not transfer	with user consent if required by law if user breaches terms of service to prevent attacks on company and service to protect rights of users and employees to fulfill a product/service order	with user consent as part of supporting miCoach.com
How: Other Companies		Garmin Device Interface SDK Communicator Plugin API	

The product teams responded to their uncertainty by designing their ecosystems to distribute similar, but largely varying physiological information. All three ecosystems created similar value for users by distributing the following information: total duration (time) exercising, calories, heart rate, and heart rate zone time. The information provided users insights during and following their exercise activities. The teams' responses differed regarding distributing additional physiological information. Suunto responded to their uncertainty by distributing unique information, while Garmin and Adidas' ecosystems did not.

The Suunto ecosystem created value with its design by distributing unique physiological information, including training effect, EPOC, VO_2 max, ventilation volume, and respiratory rate. This information created value for users by providing them insights regarding the impact of their exercise activities on their overall fitness. The Garmin and Adidas ecosystems did not distribute this same physiological information. Instead, their ecosystems created value by distributing users' speed, distance, heart rate, and calorie information. This information created value for users by providing them insights into their fitness activities. Suunto's ecosystem did not distribute speed and distance information until after the T6's launch, when the required foot pod sensor was released to the public. Given this evidence, we can reasonably speculate that when released, Suunto's ecosystem created different value for users than the Garmin and Adidas ecosystems. Once Suunto distributed speed and distance in its ecosystem, it created comparably more value than the other ecosystems.

Suunto responded to their uncertainty by designing its ecosystem to distribute environmental and related physiological information, including altitude, ascent rate, and highest altitude. This information created value for users, particularly climbers and mountaineers, by providing them insights into their performance while outdoors. The Garmin and Adidas ecosystems did not distribute this information. Given this evidence, Suunto created comparably more and unique value in its ecosystem by distributing this information.

All three product teams responded to their uncertainty by designing their ecosystems to distribute information via a web site and a physical device. While the web site components created similar value for users through providing a means to view and interact with collected activity data, the value created by the devices differed. Suunto and Garmin's watches created more value for users than Adidas' Pacer hub-type audio unit, as users could wear and use the watches while not exercising. Adidas' Pacer only created value for users when connected to the user's own music player and the ecosystem's sensors. The desktop software featured in Suunto and Garmin's ecosystems created value for users through providing an additional means to interact with and view collected activity data. Adidas' ecosystem did not include desktop software. Suunto and Garmin's responses created comparably more value for users in their ecosystems than Adidas' response.

Adidas also responded to its uncertainty by distributing information to users in a unique format, real-time audio instructions. These instructions created value for users by providing them with personalized information to improve their fitness while exercising. For example, spoken instructions told users to speed up or slow down their running speed. By doing so users' heart rate would stay in the optimal range to improve their fitness. The Suunto and Garmin ecosystems did not feature such instructions, whether distributed via audio, their desktop software, device, or web site. The Adidas ecosystem also distributed users' calories consumed, distance, pace, and cadence via audio while exercising. Adidas' response created unique and comparably more value in its ecosystem than the Suunto and Garmin responses.

Suunto and Garmin's data ecosystem designs are noted for allowing users to download their collected data at any time in the companies' SDF and CSV file formats, respectively. The teams' decision to allow users to export their collected data in these readable file formats created value for those users, and as a side effect, other companies. That value took

the form of users being able to analyze their data themselves, as well as being able to share the data with others, such as coaches and friends. For example, the design created value for users and non-users by allowing them to analyze the data with spreadsheet software, and to create metrics not calculated by and in the Suunto and Garmin ecosystems. The design characteristic lowered users' switching costs to competing systems, as users could upload the files to other instrumented fitness experiences. Correspondingly, the design characteristic created value for companies offering competing instrumented fitness experiences and services that allowed users to import their existing data. These competitors could leverage users' exported data to create value in their own fitness-related service. This characteristic of Suunto and Garmin's ecosystem designs created comparably more value than Adidas's design, which did not allow users to export their data. Adidas users could email the company for a file containing their data. Adidas' design created less value for users, as it impeded their ability to easily analyze and share their data, as well as raised their switching costs to adopt a competing instrumented fitness experience.

The three product teams responded to their uncertainty by similarly allowing users to distribute their collected per-activity data to other individuals, including fellow users and non-user members of the public. Each of the following design characteristics created value by enabling interactions amongst users and non-users, such as providing and receiving support and guidance. That value was created for both users and non-users. Users could choose to share their collected activities, such as their calories burned, heart rate, and total exercise time, with fellow users. Users could distribute their collected activity data to non-user members of the public, such as their coach or friend, via email. This design characteristic created value by allowing users and non-users to learn about and analyze users' activities. These design characteristics created similar value in the three ecosystem designs, as well as expanded the ecosystems to include non-users.

Adidas also responded to their uncertainty by allowing users to distribute their activity data to their Facebook profile, either as a status update-type message containing the activity data or as a link to their public miCoach activity page. Adidas' design created value for users and Facebook users through enabling interactions between the two. This design characteristic also created value for Facebook, as the shared activity could compel Facebook users to spend more time using the social networking site. Facebook users could engage with the shared activity data, such as through posting comments or liking the status update. Such engagement creates value for Facebook because it can then display advertisements to those users, for which the social networking site receives monetary compensation from advertisers. This aspect of Adidas' design created more value than the Suunto and Garmin designs, which did not distribute activity data to Facebook. It should be noted that Facebook did not offer such functionality when the Suunto and Garmin instrumented fitness experiences were released in 2004 and 2007, respectively.

Product teams' responses varied regarding if and how they would distribute users' collected to other companies. Such distribution could create value for the companies providing the instrumented fitness experiences, as they could sell users' data to those companies. Other companies could leverage users' data to create complementary services, creating value for

themselves and users.

Suunto pledged to not share collected data with any outside companies, curtailing its ability to create additional value for itself, users, or those companies. Garmin addressed its similar uncertainty with a different strategy. The company could share data with users' consent and under certain conditions. Garmin uniquely responded to its uncertainty by designing its ecosystem to allow other companies to access collected data to create complementary services.

Garmin's Device Interface SDK and Communicator Plugin API allowed these companies to create services, such as desktop software and web sites, leveraging users' collected data. Users could choose to adopt these other companies' services and grant them permission to access their collected data. Providing these complementary services would create value for those outside companies, including monetary value if they offered those services to users for a fee. The complementary services could create value for Garmin users as well, particularly if those services fulfill needs not addressed by the Forerunner 50, its desktop software, and Connect web site. The design created value for Garmin as well, as it brokered these interactions between users and outside companies.

As noted in the Forerunner 50 case, the Garmin product team envisioned releasing the more feature rich Connect API to allow other companies to create complementary services. Due to resource constraints and uncertainty regarding how the API would create value for the company, the Connect API was not released with the Forerunner 50. Even without the Connect API's release, Garmin's decision to allow other companies to access collected data to create complementary services created comparably much more value in its ecosystem than Suunto's decision to not share data with outside companies.

Adidas considered but opted not to pursue a strategy similar to Garmin. Adidas reserved the right to share data with companies supporting the miCoach web site or with users' consent. The product team explored developing an application programming interface similar to Garmin's Connect API, which would have similarly allowed other companies to create complementary services with users data. As with Garmin's ecosystem design, users would consent to such data sharing. The design would have created similar value for these outside companies, users, and Adidas. The team opted against modifying its ecosystem to feature such data sharing, citing a lack of budget, technical knowledge, and uncertainty regarding the long term vision of the miCoacher Pacer. Given this decision, Adidas' design created comparably less value than Garmin's, though potentially more than Suunto's design.

The product teams responded in three different ways to their uncertainty regarding designing the distribution aspects of their ecosystems. Suunto designed its ecosystem to enable users to share and easily access their collected activity data. Garmin pursued a similar uncertainty response strategy as Suunto, while also enabling other companies to create additional value for users, themselves, and Garmin. Adidas opted to wield comparably tighter control over the creation of value in the distribution aspect of its ecosystem, impeding users' ability to access their data and opting not to allow other companies to create value in the ecosystem. Garmin's response allowed it to create markedly more value in and with its ecosystem than Suunto and Adidas' responses.

7.6 Conclusion

The Suunto, Garmin, and Adidas product teams responded in different ways to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences. The teams' responses related to their beliefs regarding how to design their ecosystems to best create value. The responses created different forms of value in different ways, at different parts of the ecosystems, and for different ecosystem participants. Understanding how product teams responded to their uncertainty serves as the foundation for the next chapter, which assesses four candidate explanations for the teams' responses.

The Suunto and Adidas product teams similarly believed they could best create value through designing their ecosystems to focus on value creation for users. While both teams sought to create this value in the collection, analysis, and distribution aspects of their ecosystems, they responded with different strategies to implement their beliefs. Suunto enabled users to create additional value, while Adidas' response resulted in tighter control over value creation by and for its users. Suunto's response created comparably more value than Adidas' response.

The Garmin product team believed they could best create value through designing the Forerunner 50's data ecosystem to create value for users and companies offering complementary services to those users. Unlike the Suunto and Adidas teams, the Garmin team created this value in the collection and distribution aspects, but not analysis aspect, of its ecosystem. Garmin's response spurred the creation of additional value by users and outside companies, resulting in its ecosystem creating comparably more value than either of the Suunto or Adidas responses.

Chapter 8

Explaining the Variance

8.1 Introduction

Readers are now familiar with the three product teams' responses to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences. As detailed in Chapter 7: Identifying the Variance, teams' responses to that uncertainty varied, including how their data ecosystem designs created value and for whom. This chapter explains the variance in those responses through assessing the four hypotheses detailed in Chapter 2: Guiding Concepts. These hypotheses include User Needs, Regulations, Team Expertise, and Information Economics. Each hypothesis is assessed for each case: the Suunto T6, Garmin Forerunner 50, and Adidas miCoach Pacer.

This chapter makes the following arguments with evidence from each of the three cases and the analysis presented in Chapter 7: Identifying the Variance. The key determinant of the teams' responses to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences was their differing interpretations of the relative importance of user needs. Teams' interpretation of the relative importance of regulations were not a determinant. Teams' interpretations of the relative importance of their expertise and information economics concepts were minor determinants. Chapter 9: Conclusion explores the implications of these findings.

8.2 User Needs

The User Needs hypothesis proposes that the key determinant of teams' responses to their uncertainty was their interpretation of the relative importance of user needs. When faced with uncertainty regarding how to design the data ecosystems for the instrumented fitness experiences, product teams interacted with users to understand their needs. For this hypothesis to be supported, teams will modify the design of the data ecosystem, including what data was collected and how, and what data and information was distributed, how, and to whom, based on their interpretation of the relative importance of those needs.

Case evidence supports the User Needs hypothesis as the key determinant of the teams' responses to their uncertainty. Each team pursued a user-center design process to elicit user needs. (Baxter, Courage, and Caine 2015; Gould and Lewis 1985; Kuniavsky, Goodman, and Moed 2012; Norman and Draper 1986) Variance amongst the teams' responses is explained in part through teams' interpretation of various types of users the teams targeted for their instrumented fitness experiences and their respective needs. These user types include lead, early adopter, and early majority users both embedded within and outside the teams. (Moore 2014; Rogers 2010; von Hippel 1986) Teams' decisions to fulfill these user needs provide corresponding supporting evidence for the Team Expertise and Information Economics hypotheses.

Suunto T6

The Suunto product team's interpretation of the relative importance of user needs was the key determinant of their response. The team's decision to fulfill these user needs impacted the design of the ecosystem, including what and how data was collected and analyzed, and information was distributed, and the creation of value in the ecosystem. Due to competitive concerns these needs were primarily gathered from embedded lead users on the T6 product team rather than external, non-team members. Later during the T6's development the team gathered needs from external lead and early adopter users.

The Suunto T6 collected users' heart rate variability data due to the team's decision to fulfill users' need for actionable information that would improve their fitness. This information was distributed in the ecosystem as EPOC and training effect. The team was aware that the decision to collect this data and distribute this information would differentiate the T6 in the marketplace, potentially supporting the Information Economics hypothesis as a key determinant of the team's response. Case evidence supports that the team primarily made this decision to support user needs, and not to differentiate the T6 in the marketplace.

The T6 ecosystem collected data from multiple sensors, including a heart rate monitor, later-released foot pod sensor, and environmental sensors due to the product team's decision to fulfill users' needs to view this information during and after their exercise activities. As with collecting heart rate variability, collecting environmental data differentiated the T6 in the marketplace. The decision to collect and distribute environmental data potentially supports the Information Economics hypothesis. Evidence supports that the team primarily made the decision to collect and distribute this data to support user needs, and not to differentiate the T6 in the marketplace.

The ecosystem collected users' existing activity due to the team's decision to support users' need for the ability to analyze that data with the T6's desktop software and web site. Designing the ecosystem to allow users to import their data potentially lowered users' switching costs from competing fitness technologies. If those competing technologies allowed users to export their collected data, users could transfer their data to the T6 ecosystem. Evidence does not support that switching costs were a factor in the product team's decision, rather their desire to fulfill user needs.

The product team's interpretation of the relative importance of user needs further impacted their decisions regarding the data ecosystem design and the creation of value by that design. As noted earlier, the ecosystem distributed two forms of information, EPOC and training effect, in order to fulfill users' needs for actionable information to improve their fitness. Users' activity data was distributed via *suuntosports.com* to fulfill users' need to interact with and share their activities with others on the Internet. Providing a means for users to interact and view and share activity data with one another is potential supporting evidence for the Information Economics hypothesis. Enabling these interactions could spur positive network effects on the T6's multisided platform, *suuntosports.com*. Likewise, the ecosystem design's ability for users to share their activity data with members of the public could foster interactions and spur positive network effects. Case evidence does not support that the team made these decisions in order to primarily spur positive network effects, rather to support users' needs.

Lastly, the T6 data ecosystem featured users' ability to export their collected data at any time in a readable file format. Providing this feature arose from the product team's decision to support users' need for such functionality. As further discussed later in this chapter, the team's decision regarding this aspect of the data ecosystem design provides potential supporting evidence for the Regulations hypotheses. Evidence supports that the team made this design decision to fulfill user needs, not due to regulatory requirements.

The Suunto product team's interpretation of the relative importance of user needs was the key determinant of the team's response to its uncertainty regarding designing the T6 ecosystem. The team primarily gathered these user needs from members of the product team itself, and secondarily from users outside the team and company. Evidence does not indicate that these two groups of users exhibited different needs. The product team's interpretation of the relative importance of a subset of these needs, particularly with respect to offering users differentiating features and means to share activity data with users and non-users, offer supporting evidence for the Information Economics hypothesis. These design decisions stemmed from the team's interpretation of those needs.

Garmin Forerunner 50

Evidence supports that the Garmin Forerunner 50 product team's interpretation of the relative importance of user needs was a key determinant of its response. The team primarily gathered these user needs from team members, themselves early adopters of fitness technologies, and from a small pool of new fitness technology users inside and outside the company. This latter group could be characterized as later adopting, early majority users. These user groups exhibited different needs, and the team's interpretation of and prioritization of fulfilling these varying needs impacted their response.

The product team's interpretation of the relative importance of user needs impacted what and how data was collected in the Forerunner 50 data ecosystem. The team's decision to fulfill users' fitness needs, regardless of whether they were experienced or new fitness technology users, necessitated the collection of users' heart rate and cadence-related data. The ecosystem

would analyze this data and return fitness-related information, such as calories, to users. Fulfilling these needs also impacted how data was collected in the ecosystem, as they required chest-worn heart rate and shoe-worn foot pod sensors.

The data collection design also reflects the team's decision to forego fulfilling a user need that was a hallmark of prior Garmin devices. Up to the release of the Forerunner 50 in 2007, all of Garmin's consumer devices collected users' location data. Users could interact with that data on these devices. Just prior to the Forerunner 50's development the product team determined users needed to interact with their location data on a web-based map. Garmin acquired an outside company, MotionBased Technologies, providing such a service.

Fulfilling users' location needs in the Forerunner 50 data ecosystem design would require a GPS sensor to collect location data, which would have required a retail price that the product team believed would be too high for their target early majority users. The team's decision to forego fulfilling this need meant the ecosystem design would not collect, nor would it be able to distribute, users' location data. As detailed later in this chapter, this decision is supporting evidence for the Information Economics hypothesis being a key determinant of the team's response.

The data collection aspect of the Forerunner 50 ecosystem design features users' ability to import their existing activity data. This design attribute is a result of the product team's decision to support their own early adopter user need to import their activity data for analysis by the Training Center desktop software and Connect web site. These early adopters already had collected data, which would not necessarily be the case for the Forerunner 50's target early majority users buying their first fitness device. Similar to the T6, designing the ecosystem to allow users to import their data potentially lowered users' switching costs from competing fitness technologies if those competing technologies allowed users to export their collected data. Evidence does not support that switching costs were a factor in the product team's decision, rather their desire to fulfill user needs.

The distribution of data in the Forerunner 50 data ecosystem further reflects the product team's interpretation of multiple user needs. As noted earlier, that distribution did not include location data due to the team's decision to forego fulfilling users' location needs. Data was distributed to users via the ecosystem's Training Center desktop software and Connect web site. While the ecosystem supported interactions between users and non-users, evidence does not support that the product team designed the ecosystem to foster these interactions in order to spur positive network effects. Instead the team sought to support users' need to share and exchange activity data with others, such as their friends and coaches.

The product team designed the data ecosystem to fulfill users' need for ready access to their collected activity data in a readable file format. Users could download their collected activity data at any time and use standard spreadsheet software to interact with their data, as well as share the data with others. Similar to the Suunto T6, the team's decision provides potential supporting evidence for the Regulations hypothesis. The team made this design to fulfill user needs, and not due to regulatory requirements regarding users' access to their data. Evidence does not support that the team was concerned that the decision lowered users' switching costs to competing instrumented fitness experiences. The team designed

the ecosystem to allow the ready export of collected activity data in order to fulfill user needs.

During the Forerunner 50's development the product team considered modifying the ecosystem design to allow outside companies access to users' data via a suite of application programming interfaces. Members of the product team from the acquired company Motion-Based argued that those outside companies could create complementary services fulfilling users' needs that Garmin did not have the resources or interest in fulfilling. As detailed later in this chapter, these team members also argued that designing the ecosystem to distribute collected activity data to outside companies with users' permission would help spur device sales. Ultimately the product team leader opted not to allocate resources to creating all of the desired application programming interfaces, citing resource constraints and the desire for the team to focus on fulfilling already-identified user needs. Only one application programming interface and software development kit was added to the data ecosystem. This decision is revisited later in the chapter, as it is potential supporting evidence for the Information Economics hypothesis.

The Garmin product team's interpretation of the relative importance of user needs was a key determinant of the team's response to its uncertainty regarding designing its data ecosystem. Key aspects of the design, including users' ability to import and export their data, fulfilled the needs of early adopter users' such as those on the product team. The design did not fulfill those users' location-related needs, as the team prioritized introducing a lower-cost device that would appeal to later-adopting early majority users. The team's decision regarding location needs and device cost is revisited later in the chapter.

Adidas miCoach Pacer

The Adidas product team's interpretation of the relative importance of user needs was the key determinant of the team's response to their uncertainty. The team, referred to as AIT, fielded these user needs from team members themselves and users outside the team in the United States, Germany, and China. These sources of user needs ranged from non-athletes who had not used fitness technologies, particularly users outside the company and on the Molecular team AIT hired to assist with the Pacer project, to experienced athletes on the team who were lead and early adopters of fitness technologies. The team reconciled these varying user needs to focus on the miCoach Pacer's target users, which can be characterized as early majority, first-time users of fitness technologies. The team's decisions to fulfill these needs impacted how and what information was distributed to users in the ecosystem.

A key determinant of the miCoach Pacer's data ecosystem design was the product team's decision to fulfill users' need for coaching information. The team found through its interactions with users, both on the team and not, who were less experienced with exercising and fitness technologies that they were uncertain regarding how to exercise. For example, these users did not know how far to run or at what speed to improve their fitness. Users cited that they needed this information while exercising, which was not available with other companies' instrumented fitness experiences. AIT's decision that the miCoach Pacer would

fulfill this need differentiated the miCoach Pacer in the market. As detailed later in this chapter, the decision provides supporting evidence for the Information Economics hypothesis. The decision impacted what and how the ecosystem collected data, as well as what and how the ecosystem distributed information. Fulfilling this need for coaching information required collecting users' heart rate and cadence data. AIT decided to use Dynastream's ANT+ technology and sensors to collect this data, a decision that is examined later in this chapter as potentially supporting the Team Expertise hypothesis.

AIT determined that it was not expert regarding creating such coaching information, and turned to outside company Athletes' Performance Institute to provide this information in the ecosystem. As detailed later in this chapter, AIT's decision to use Athletes' Performance Institute's analysis is potentially supporting evidence that Team Expertise was a determinant of the team's response to its uncertainty.

AIT modified the distribution aspect of the ecosystem design in order to distribute real-time coaching information to users. Alongside returning information to users via the miCoach web site after exercising, the ecosystem converted Athletes' Performance Institute's coaching information into audio instructions that were then returned to users in real-time via the Pacer device. Distributing this real-time audio coaching information in the ecosystem differentiated the miCoach Pacer in the market, potentially supporting Information Economics as a determinant of the team's response to their uncertainty. This decision is further assessed later in this chapter.

The distribution aspect of the miCoach Pacer data ecosystem design also reflected AIT's interpretation of users' need regarding sharing their collected activities with miCoach users and non-users. Through a user study Molecular found that users sought the ability to interact with other people regarding their fitness activities. AIT decided to fulfill this need by allowing users to share their activity data with other miCoach users, as well as non-users. AIT modified the ecosystem design to allow users to distribute their activity data via email and as a status update to the social networking site Facebook. Molecular believed that such sharing would also help miCoach grow, potentially supporting Information Economics as a determinant of the team's response. This decision is assessed later in this chapter.

The data ecosystem design for the miCoach Pacer differed from that of the other cases' designs in that users could not import or readily export their data. These aspects of the miCoach Pacer data ecosystem design reflect AIT's interpretation of user needs. During the concept stage AIT envisioned the miCoach Pacer as a figuratively open platform, where users and their data easily flowed in and out of the system. Users would be able to import their data, export it, as well as share it with outside companies creating complementary services. AIT and Molecular's interactions with target miCoach Pacer users, first time users of fitness technology, did not reveal that users had such needs. As a result AIT decided not design the ecosystem to support these needs. AIT's decision was also guided by resource concerns and uncertainty regarding the future of fitness technologies at Adidas.

In summary, AIT's interpretation of the relative importance of user needs was the key determinant of the team's response. AIT designed the ecosystem to fulfill users' need for real-time coaching information and the ability to share activity data with others. These designs

decisions primarily reflect the team's interpretation of first-time fitness technology users' needs and not the needs of more experienced users as on the AIT and Molecular teams. AIT's decision to fulfill these user needs differentiated the miCoach Pacer in the market and resulted in the ecosystem design featuring the contributions of two outside companies, potentially supporting the Information Economics and Team Expertise hypotheses. The relationships between the team's response to its uncertainty and these hypotheses are further assessed later in this chapter.

Summary

Evidence supports the User Needs hypothesis as the key determinant of the product teams' responses to their uncertainty regarding designing their data ecosystems. Each of the teams addressed their uncertainty by interacting with users to ascertain their needs, then interpreting the relative importance of those needs to guide their design decisions. These interpretations impacted what and how data was collected in the ecosystems, and what data and information was distributed, how and to whom.

Response variance amongst the cases is explained in part through which type of users the teams targeted for their instrumented fitness experience. The Suunto T6 targeted early adopters, and the ecosystem design is noted for its ability for users to import and export their data to the ecosystem. The T6 ecosystem returned comparably more advanced fitness information than those instrumented fitness experiences targeting early majority users. The Suunto T6 returned training effect and EPOC in order to help its early adopter users understand the impact of training activities on their fitness. The Adidas miCoach Pacer returned in-situ instructions to its early majority users. Adidas users could not import or readily export their data, but could share it with users and non-users. Garmin targeted early majority users and its ecosystem design bridged both their needs and those of early adopters. The Garmin ecosystem returned familiar forms of fitness information, such as calories and distance, for early majority users. It fulfilled early adopters' need to import and export their data, but did not fulfill their need for mapped route information.

Each of the design decisions noted above are principally explained by teams' interpretation of the relative importance of user needs, supporting the User Needs hypothesis as the key determinant of the teams' responses to their uncertainty. While a subset of design decisions present supporting evidence for the Team Expertise and Information Economics hypotheses, each decision stemmed primarily from the teams' interpretation of user needs and not their interpretation of related information economics concepts. These decisions are explored later in this chapter and bolster support for the User Needs hypothesis.

8.3 Regulations

The Regulations hypothesis proposes that the key determinant of product teams' responses to their uncertainty was their interpretation of the relative importance of regulations regarding

the collection and use of personal data. Product teams facing such uncertainty look to relevant regulations regarding the collection and use of personal data to inform their design decisions. For this hypothesis to be supported, product teams will modify the design of the data ecosystem based on their interpretation of the relative importance of those regulations.

Evidence does not support the Regulations hypothesis as a key determinant of teams' responses. All of the product teams identified and consulted regulations regarding the collection and use of personal data. None of the teams made significant changes to their ecosystem designs based on their interpretation of the relative importance of those regulations. The Adidas product team made one minor modification to their ecosystem design based on their interpretation of regulations. Given this evidence, the Regulations hypothesis should be considered non-determinant of the team's responses.

Suunto T6

Evidence does not support that the Suunto product team's interpretation of the relative importance of regulations was a determinant of its response to its uncertainty. The team's ensuing data ecosystem design surpassed regulatory requirements due to the team's interpretation of the relative importance of user needs. The team identified those user needs during the T6's concept phase, and later during the development stage consulted European Union and Finnish regulations regarding the collection and use of personal data. Per guidance from Suunto lawyers, the team turned to Finland's Personal Data Act 523/1999 because the regulations were perceived to be the most specific and stringent amongst those in the T6's primary markets of the European Union and United States. Through complying with these regulations the T6 would also comply with regulations perceived as less-stringent elsewhere in the world.

In accordance with Finnish regulations, the ecosystem design continued to only collect data from users with their permission and only data that related to the T6 experience. The ecosystem continued to not share data with other companies without users' consent, as well as provide users with ready access to their collected data. Each of these design characteristics arose from the team's prior decisions to fulfill user needs. The team gathered these needs primarily from T6 product team members and secondarily from users outside the company. As noted in the case, the team characterized T6 users as early adopters of fitness technology.

Two earlier-referenced aspects of the ecosystem design figuratively surpassed requirements stipulated by Personal Data Act 523/1999. For both design aspects the team cited an interest in fulfilling user needs as the reason for surpassing these regulatory requirements. First, Suunto publicly pledged in its product documentation to never share collected data with outside companies, even though regulations stipulated that the company could with users' consent. During the development phase the team designed the data ecosystem such that it would not share collected data with outside companies, including Firstbeat Technologies, the provider of the analysis that converted users' data into training effect and EPOC. The product team embedded Firstbeat's data analysis algorithms in its desktop software and web site, preventing Firstbeat from accessing users' data. Second, the ecosystem design

allowed users to download their collected activity data at any time, even though regulations permitted the company to instead field users' data requests and then process those requests in a timely manner. Providing users a means to download their collected data at any time surpassed regulatory requirements.

Evidence does not support that the Suunto product team's interpretation of the relative importance of regulations was determinant of their response. During the concept phase the team designed key aspects of the ecosystem based on its interpretation of the relative importance of user needs. The team did not modify the ecosystem design after consulting regulations during the development phase. Evidence supports that the team designed two key aspects of the ecosystem design to surpass those regulatory requirements based on its interpretation of the relative importance of users' needs.

Garmin Forerunner 50

Evidence does not support that the Forerunner 50 product team modified its data ecosystem design based on its interpretation of the relative importance of regulations. Similar to the Suunto case, evidence supports that the team surpassed regulatory requirements based on its interpretation of user needs. The team identified those specific user needs during the concept phase. The team also consulted relevant regulations in the United States and European Union during the concept phase. While it is uncertain from the case evidence which regulations the team consulted, we can reasonably speculate that they included the European Union's Data Protection Directive 95/46/EC. As noted in Chapter 2: Guiding Concepts, the Directive was at the time the preeminent personal data-related regulation regarding products and services offered to consumers in the European Union.

The case evidence indicates that the product team first consulted regulations regarding what would become the Forerunner 50 early in its concept phase. On acquiring MotionBased the product team assessed the web service's compliance with regulations regarding what and how it collected users' data, and what and how it distributed data and information and to whom. The team found that the service complied with regulations for the United States and European Union, even though the acquired MotionBased team had not consulted regulations while developing and offering its service. Instead the MotionBased team relied on its own needs and beliefs as lead users and early adopters of fitness technologies to guide its design efforts.

Of key relevance to the Forerunner 50's data ecosystem design, MotionBased was designed to fulfill users' need to download their collected activity data at any time. The Forerunner 50 team found that this aspect of the data ecosystem design surpassed regulatory requirements regarding providing users access to their collected data. As with the Suunto case, Garmin was only required to provide a means for users to request their collected data, and the company could then fulfill that request in a reasonable period of time.

The product team maintained this functionality in the Forerunner 50 data ecosystem in spite of the potential economic downsides for the company. As detailed in the earlier assessment of value creation in the Forerunner 50's data ecosystem, this functionality created

value for users by lowering their switching cost to another instrumented fitness experience. Such functionality posed an economic downside for Garmin, as those users could switch to a competing instrumented fitness experience.

The Forerunner 50 product team could have modified the ecosystem to not allow users such ready access to their data while still complying with regulations. It is unclear from the case evidence why the product team opted not to modify the ecosystem design. We can reasonably speculate that the team sought to continue fulfilling users' needs, particularly those of early adopters who expressed such need. Perhaps the team believed removing such functionality would contribute to existing users switching to a competing instrumented fitness experience.

Evidence does support that the product team's interpretation of the relative importance of regulations was a determinant of the Forerunner 50's data ecosystem design. The team consulted regulations during the concept phase, and opted not to modify the ecosystem to curtail functionality that lowered users' switching costs to competing instrumented fitness experiences. This functionality allowing users to readily access their collected data surpassed regulatory requirements. It is reasonable to believe that the team maintained this functionality in order to fulfill users' needs.

Adidas miCoach Pacer

Evidence supports that the Adidas product team's interpretation of the relative importance of regulations was minimally determinant of the team's response to its uncertainty regarding the miCoach Pacer's data ecosystem design. The team modified the collection aspect of the ecosystem design in order to better ensure the miCoach Pacer complied with per-country regulations and to prevent children from using the miCoach Pacer

During the miCoach Pacer's concept and development phases the team interacted with the company's legal team to identify relevant regulations. The product team decided that since the miCoach Pacer would be released globally it would comply with the strictest regulatory requirements, which the product and legal teams perceived as existing in the European Union. Similar to the Garmin case, it is uncertain from the case evidence which specific regulations the team consulted. We can again speculate that these regulations include the European Union's Data Protection Directive 95/46/EC. Since Adidas is based in Germany, we may also reasonably speculate that the team consulted the country's Federal Data Protection Act.

Based on its interpretation of the relative importance of these regulations, the product team modified the data collection aspect of the ecosystem design. First, the ecosystem was modified to collect a user's country so that the service could comply with specific per-country regulations. Second, the ecosystem was modified to collect user age. This personal data was collected in order to screen for and prevent users under thirteen years of age from using the miCoach Pacer. The product team determined that the miCoach Pacer would not be for children, though it is unclear why from the case evidence. We can reasonably speculate that the team sought to forego having to comply with costly regulations regarding providing

services to children. For example, as noted in Chapter 2: Guiding Concepts, the United States' Children's Online Privacy Protection Act (COPPA) applied to web-based services for individuals under thirteen years of age. The ecosystem design did not prevent users under thirteen years of age from using the miCoach Pacer, as such users could enter any age above thirteen and be allowed to join and use the miCoach Pacer.

Unlike the Suunto and Garmin cases, evidence does not support that the miCoach Pacer data ecosystem surpassed regulatory requirements. Of note in comparison to the other cases, the ecosystem was not designed to allow users to readily access their collected data. Per European Union regulations, miCoach Pacer users could submit a request for their collect data via email to Adidas. The company would then send an email to the user with a file containing their collected data in a readable format. Adidas miCoach Pacer users could not download their collected data at any time, unlike Suunto and Garmin users. As noted in the case, the product team did not provide ready access to collected data similar to Suunto and Garmin because it was not requested by users.

Case evidence supports that the Adidas product team's interpretation of the relative importance of regulations was a minor determinant of the team's ecosystem design response. After consulting European Union regulations, the team modified the data collection aspect of the ecosystem. The ecosystem collected a user's country and age in order to ensure the ecosystem complied with regulations specific to that user's country and to prevent children from using the miCoach Pacer. Evidence does not support that the team's desire to fulfill user needs led it to design the ecosystem to surpass regulatory requirements, unlike the Suunto and Garmin ecosystems.

Summary

The Regulations hypothesis proposes that the key determinant of team's response to their uncertainty regarding designing their data ecosystem was a product team's interpretation of the relative importance of regulations regarding the collection and use of personal data. This hypothesis was not supported in the three cases. Evidence in the Suunto and Garmin cases supports that these ecosystem designs surpassed regulatory requirements in order to fulfill user needs. The Adidas product team made minimal modifications to the data collection aspect of its data ecosystem design based on its interpretation of European Union regulations. These modifications are supporting evidence for Regulations being a minor determinant of the Adidas team's response.

8.4 Team Expertise

The Team Expertise hypotheses proposes that the key determinant of teams' responses to their uncertainty is their interpretation of the relative importance of their own expertise, the knowledge they have acquired through prior experiences. When faced with the uncertainty of designing their data ecosystems, a product team relies on their interpretation of their

internal expertise to guide their design decisions. For this hypothesis to be supported, a product team will assess its expertise regarding aspects of the data ecosystem design. A product team that is not expert regarding specific aspects of the design will rely on other companies' expertise to fulfill those aspects. As described in Chapter 2: Guiding Concepts, the team may pursue a Sourcing or Acquiring strategy to integrate that expertise in the ecosystem design. (Dahlander and Gann 2010)

Evidence does not support the Team Expertise hypothesis as a key determinant. None of the teams' responses were determined primarily by their interpretation of the relative importance of their expertise. Instead, teams' decisions to fulfill specific user needs led them to assess their expertise regarding designing their data ecosystem to fulfill those needs. In each case the product team modified the design of its ecosystem to feature outsiders' expertise that could fulfill those user needs. Teams pursued Acquiring strategies, financially compensating these companies for their expertise. Given this evidence, the Team Expertise should be considered a minor determinant of the teams' responses.

Suunto T6

Evidence does not support that the T6 product team's interpretation of the relative importance of its expertise was the key determinant of its response. The ecosystem design featured the contributions of multiple outside companies as a result of the product team's assessment that it was not expert regarding fulfilling specific user needs. The product team's decision to fulfill those user needs led it to incorporate these outside companies' expertise into the data collection, analysis, and distribution aspects of the T6 data ecosystem design. The team pursued Acquiring strategies with these companies.

The data collection aspect of the data ecosystem featured Dynastream Innovation's foot pod sensor and wireless transfer technology. The product team's decision to feature Dynastream's technologies stems from the team's decision to fulfill users' need for wirelessly collecting and transferring data from multiple sensors. The team assessed that it did not have the needed expertise to develop these technologies itself, so it turned to Dynastream to help fulfill these needs. The product team pursued an Acquiring strategy with Dynastream, providing financial compensation to Dynastream in exchange for their expertise.

Suunto did not rely entirely on Dynastream's expertise for the data collection aspect of the ecosystem, and leveraged expertise it acquired during an earlier project to design the ecosystem's heart rate sensor. Note that the team did not include a heart rate sensor in the ecosystem simply because it considered itself expert, which would be supporting evidence for the Team Expertise hypothesis being a determinant of the team's response. The heart rate sensor fulfilled users' need for heart rate-related information, such as heart rate zone and calories.

Suunto also turned to outside company Nordic Semiconductor for its expertise developing the semiconductor that would analyze users' data in the T6 watch. The Suunto team assessed that it was not expert creating technology that could collect and analyze data from multiple sensors and display it on the users' watch. This was a key user need for the T6, so in order to

fulfill the need the product team turned to Nordic Semiconductor. As with the Dynastream relationship, Suunto pursued an Acquiring strategy where it financially compensated Nordic Semiconductor for its expertise.

The product team also turned to an outside company for its expertise analyzing users' data. The ecosystem featured Firstbeat Technologies' analysis converting users' heart rate variability data into training effect, EPOC, and other forms of information. The product team identified that users needed actionable fitness information, and assessed that it was not expert developing such information itself. The team decided to fulfill this user need, and given its expertise assessment, modified the ecosystem design to feature Firstbeat's analysis. Suunto pursued a Sourcing strategy with Firstbeat. As discussed later in this chapter, training effect and EPOC are assessed as supporting evidence for the Information Economics hypothesis because they differentiated the T6 in the marketplace. The inclusion of Firstbeat in the design stems from the team's decision to fulfill users' need for information that would improve their fitness, and then the team's expertise assessment.

Very early in the T6's concept phase the product team identified that users of its existing devices sought the ability to view and interact with their collected fitness activity data online, and to be able to share that data with friends and coaches. The product team decided to fulfill this need and acquired an outside company, Meiga Innovations, who provided such a service. This service would become the distribution aspect of the T6 data ecosystem. While it is unclear from the case evidence why Suunto acquired Meiga, we can reasonably speculate that it related to the product team's assessment of the relative importance of user needs and its expertise. At the time in 2002 it appears that no other company offered such a service in Europe or globally. Meiga held expertise that was likely not widespread. Suunto pursued an Acquiring strategy with Meiga, literally acquiring the company rather than licensing its expertise. It is unknown from the case evidence why the company acquired and did not license Meiga's expertise.

The product team's interpretation of the relative importance of its expertise was a determinant of the team's response to its uncertainty, but not the key determinant. Evidence supports that the team pursued Acquiring strategies with multiple companies as a result of its assessment that it was not expert regarding fulfilling user needs.

Garmin Forerunner 50

The Garmin product team's interpretation of the relative importance of its expertise was not a key determinant of its response to its uncertainty. Garmin acquired two companies featured in the design, MotionBased Technologies and Dynastream Innovations, as a result of the product team's decision to fulfill user needs for which the team did not consider itself expert. The team pursued Acquiring strategies with these companies, literally acquiring them outright. Evidence supports that the Team Expertise hypothesis was a minor determinant of the team's response.

The data collection aspect of the Forerunner 50 data ecosystem featured Dynastream's chest-worn heart rate monitor and shoe-worn foot pod sensors, ANT+ wireless transfer tech-

nology, and watch. The product team turned to Dynastream for these ecosystem components in order to fulfill users' data collection needs. The team assessed it was not expert fulfilling these needs itself, as for its past fitness devices it had relied on outside companies' expertise. Dynastream could fulfill these user needs, leading in part to Garmin's decision to acquire the company. As detailed later in this chapter, Garmin's decision to acquire the company is also supporting evidence for the Information Economics hypothesis. Dynastream's inexpensive watch and sensors would allow the team to pursue a penetration pricing strategy with the Forerunner 50, pricing the device low relative to competing fitness technologies

The product team's assessment of its expertise was a determinant of the distribution aspect of the Forerunner 50 data ecosystem design. Early in the concept stage the product team identified that users sought the ability to interact with their collected fitness data on a web site and be able to share that data with friends and coaches. The team assessed that it did not have the expertise to fulfill this need, so it acquired MotionBased, an outside company with this expertise. MotionBased's web service at the time of the acquisition had thousands of users, many of whom were Garmin fitness device owners. The product team first bundled MotionBased's web service with its existing devices, then fully integrated the renamed Connect web service into the Forerunner 50 data ecosystem. The team's assessment of the relative importance of its expertise was a determinant of the Connect distribution aspect of the data ecosystem, but as a result of its decision to fulfill users' need for a web-based service to interact with their collected fitness data. Such evidence supports Team Expertise as a minor determinant of their response.

As with the Suunto T6 case, the Forerunner 50 product team's interpretation of the relative importance of its expertise was a determinant, but not key determinant, of the team's response. The team pursued Acquiring strategies with two companies based on its assessment of its expertise regarding fulfilling user needs.

Adidas miCoach Pacer

Evidence does not support that the Adidas Innovation Team's interpretation of the relative importance of its expertise was a key determinant of the team's response to its uncertainty. The team's interpretation of the relative importance of its expertise was a minor determinant as a result of the team's interpretation of the relative importance of user needs. The team pursued an Acquiring strategy with multiple outside companies in order to fulfill these needs. As with the Suunto and Garmin cases, evidence supports that the Team Expertise hypothesis was a determinant, but not key determinant, of the team's response to its uncertainty.

The miCoach Pacer ecosystem collected data via sensors developed by the team itself and by Dynastream. These sensors would fulfill users' need for collecting their fitness data, such as their heart rate and pace. The team assessed that it was expert regarding developing the needed heart rate monitor sensor, and assessed that it was not and should not develop the expertise needed for the ecosystem's foot pod sensor. For the latter, the team believed that such sensors were commodities in the market and turned to Dynastream to provide those sensors. The team assessed that it was not expert regarding developing the wireless

transferring technology that would fulfill users' need for collecting their fitness data, and again turned to Dynastream for its expertise. While it is unclear from the case evidence, the product team likely pursued an Acquiring strategy with Dynastream and paid the company a fee for supplying the sensor and wireless technology.

The Adidas team also assessed it was not expert regarding fulfilling users' need for insightful information that would improve their fitness. As a result, the ecosystem featured the analysis of outside company Athletes' Performance Institute. The product team pursued an Acquiring strategy with Athletes' Performance Institute, financially compensating the company for its expertise. The ecosystem was designed to distribute the results of this analysis to users as real-time audio-based coaching instructions. As examined later in this chapter, the feature differentiated the miCoach Pacer in the market and provides supporting evidence for the Information Economics hypotheses as determinant of the team's response. The ecosystem design featured Athletes' Performance Institute's analysis as of a result of the team's decision to fulfill users need for this information, and the team's ensuing interpretation of the relative importance of its expertise fulfilling that need. This evidence supports User Needs over Team Expertise as the key determinant of the Adidas team's response to its uncertainty.

The Adidas Innovation Team's interpretation of the relative importance of its expertise was a determinant of its response, but evidence does not support that it was the key determinant. The product team pursued Acquiring strategies with multiple companies based on its assessment of its expertise fulfilling user needs.

Summary

Team Expertise was not a key determinant of the three teams' responses to their uncertainty. Evidence supports that product teams' interpretation of the relative importance of their expertise was a minor determinant of their responses. All three teams pursued Sourcing strategies to include outside companies' expertise in their ecosystems. The team pursued these strategies as a result of their assessment that they were not expert regarding fulfilling user needs themselves. In order to fulfill those user needs product teams determined that they would need outside companies' expertise. In light of this evidence, the Team Expertise hypothesis should be a considered a minor determinant of the responses.

8.5 Information Economics

The Information Economics hypothesis proposes that the key determinant of a product team's response to its uncertainty is the team's interpretation of the relative importance of key concepts from information economics theory. These concepts include multisided platforms, network effects, penetration pricing, and differentiation. When faced with uncertainty regarding designing their data ecosystem, product teams pursue strategies related to these concepts.

The team envisions their instrumented fitness experience as a multisided platform that enables interactions between users sharing and viewing one another's fitness activities. (Armstrong 2006; Evans 2003; Gawer 2009; Hagiwara and Wright 2015; Rochet and Tirole 2003) These interactions spur same-side network effects. (Eisenmann, Parker, and Alstyne 2006; Gawer 2011; Parker and Alstyne 2008; Parker and Van Alstyne 2010; Shapiro and Varian 1999) The team pursues a penetration pricing strategy to spur user adoption and same-side network effects. (Eisenmann, Parker, and Alstyne 2006; Shapiro and Varian 1999) The team differentiates the instrumented fitness experience in the market in order to further spur user adoption and same-side network effects. (Shapiro and Varian 1999) Lastly, the team expands the number of types of users in the ecosystem to spur cross-side network effects. (Eisenmann, Parker, and Alstyne 2006; Rochet and Tirole 2003)

Evidence supports that the Information Economics hypothesis was a determinant of teams' responses to their uncertainty, but only a key determinant in Garmin's response. The Garmin Forerunner 50 ecosystem design reflects the team's early concept stage decision to pursue a penetration pricing strategy and development stage decision to expand the number of types of users in the ecosystem to spur cross-side network effects. The Suunto and Adidas teams' responses were determined by their interpretation of the relative importance of user needs. Both teams chose to fulfill user needs that then differentiated their instrumented fitness experiences in the market. These decisions are evidence supporting User Needs as a key determinant of the two responses, with Information Economics a minor determinant.

Suunto T6

The Suunto product team's interpretation of the relative importance of information economics concepts was not a key determinant of the team's response. Evidence does not support that the team pursued a penetration pricing strategy, as the T6 was priced higher than competing fitness technologies. The team did not consider expanding the number of user types in the ecosystem in order to spur cross-side network effects. Evidence supports that the team designed the ecosystem as a multisided platform to spur positive network effects, as well as to differentiate the T6 in the marketplace. These design decisions arose principally from the team's interpretation of the relative importance of user needs and not information economics concepts.

The team designed the T6 as a multisided platform enabling interactions between users interested in sharing and viewing one another's fitness activities, as well as between users and non-user members of the public. These design decisions could be considered supporting evidence for the Information Economics hypothesis, as enabling such interactions could spur positive network effects amongst users. Users would value the ability to share their activities with users and non-users, while users and non-users would value the ability to interact with these shared activities. Evidence supports that these design decisions were principally guided by the team's interpretation of the relative importance of user needs and not the related information economics concepts. Users sought the ability to interact with users and non-users, and the product team decided to fulfill these needs in the ecosystem. This decision

is primarily supporting evidence for the User Needs hypothesis, and secondarily evidence for the Information Economics hypothesis.

The product team designed the T6 ecosystem to distribute multiple forms of data and information, including environmental data such as altitude and barometric pressure, and the physiological information EPOC and training effect. No other fitness technologies at the time distributed these forms of information, thereby differentiating the T6 in the market. These design characteristics could be considered supporting evidence for the Information Economics hypothesis, however they arose from the team's interpretation of the relative importance of user needs. Users expressed the need for this environmental data and insightful information to improve their fitness. The product team's decision to fulfill these needs led to the T6's differentiation in the market. Evidence does not support that the team sought to differentiate the T6 prior to identifying this user need.

The team did not pursue a penetration pricing strategy, nor did it strive to spur cross-side network effects through expanding the number of user types in the ecosystem. Evidence supports that the team designed the ecosystem as a multisided platform and to differentiate it in the marketplace, however those design decisions arose principally from its interpretation of the relative importance of user needs and not the related information economics concepts.

Garmin Forerunner 50

Evidence supports Information Economics as a key determinant of the Garmin team's response to its uncertainty. The product team decided to pursue a penetration pricing strategy to spur adoption and same-side network effects. The team sacrificed a differentiating feature that fulfilled a user need in order to pursue this pricing strategy. It sought to spur cross-side network effects by designing the ecosystem to allow users to share their collected activity available with outside companies, who could then create complementary services for those users. Each of these decisions are principally explained by the product team's interpretation of the relative importance of information economics concepts. Similar to the Suunto T6 ecosystem design, the team's decision to design the ecosystem as a multisided platform enabling interactions amongst users arose from the team's interpretation of the relative importance of user needs.

Early in the Forerunner 50's concept stage the product team determined that it would develop a new fitness device to target early majority users in what it perceived was a maturing fitness technology market. The team believed that these users would be more price sensitive than the company's existing early adopter-type users, and thus less willing to spend hundreds of dollars on their first fitness device. The team further believed that introducing a lower priced device would help spur adoption amongst these users. Increasing the number of users would contribute to positive same-side network effects, as these users would then share and view other users' activities on their Connect web service. This decision to pursue a penetration pricing strategy supports the Information Economics hypothesis as a key determinant of the team's response to its uncertainty.

Evidence supports that the team sacrificed differentiating the ecosystem in order to pursue this penetration pricing strategy. At the time the team's existing consumer technologies featured the ability to display a user's route on a map. This feature fulfilled a key user need and differentiated Garmin's consumer technologies in the market. The feature required a global positioning system chip, whose cost at the time was prohibitive. Modifying the ecosystem design for this feature would have led to a price that the team believed would not have appealed to early majority users who were new to fitness technologies. In order to release a low priced device the team decided to remove the GPS chip from the data collection aspect of the ecosystem, as well as remove the corresponding mapping feature from the distribution aspect of the ecosystem. This decision to forsake differentiating the Forerunner 50 does not support the Information Economics hypothesis.

During the Forerunner 50's development phase the team redesigned aspects of the ecosystem to spur cross-side network effects. These redesign efforts are supporting evidence for the Information Economics hypothesis as a determinant of the team's response. The Connect team within the Forerunner 50 team created a Device Interface software development kit, Communicator Plugin application programming interface (API), and redesigned the ecosystem's Connect web service atop a collection of APIs. This collection of APIs was referred to as the Connect API. These technologies would allow outside companies to create services that accessed data on users' Garmin devices and the Connect web service. A few months before the Forerunner 50's release Garmin launched its developer web site, where these outside companies could learn about and discuss these technologies.

The Connect team primarily undertook these redesign efforts because it believed outside companies' complementary services would spur sales of Garmin fitness devices. These companies could create value for themselves by offering services to Garmin device users. These services could create value for users through offering features and functionality not found in Garmin's desktop software and Connect service. The Connect team believed that enabling interactions between these two different types of users, consumer-users and outside companies, would create value for Garmin in the form of increased device sales. The Connect team's beliefs are offer supporting evidence for the Information Economics hypothesis' interpretation of cross-side network effects as a determinant of the team's response to its uncertainty.

Readers will recall from the case that Garmin did not release the Connect API to outside companies along with the Forerunner 50's release to consumers. The team did release the Device Interface software development kit and Communicator plugin. The decision to not release the Connect API stemmed primarily from the Connect team's challenges creating the API and to a lesser degree from the product team's uncertainty regarding if and how the API would spur device sales. Evidence indicates that the Forerunner 50 team and Garmin management were not convinced that the API would contribute to increased device sales, in spite of the earlier-referenced arguments put forth by the Connect team. The product team decided that the Connect team should instead focus its efforts on supporting the development of future fitness devices. The Forerunner 50 team's decision regarding the Connect API lessens the strength of the evidence supporting the Information Economics

hypothesis as determinant of the team's response.

In conclusion, evidence supports the Information Economics hypothesis as a key determinant of the Garmin team's response. The team sought to spur same-side and cross-side network effects through pursuing a penetration pricing strategy and developing APIs for outside companies to create complementary services, respectively. The former is evidence for the Information Economics hypothesis as a key determinant of the team's response, as the team sacrificed fulfilling a user need with its pricing strategy. Some but not all of the APIs were released with the Forerunner 50, offering minor support for the Information Economics hypothesis. The team's interpretation of regulations, user needs, or their own expertise do not explain these decisions.

Adidas miCoach Pacer

Evidence supports the Information Economics hypothesis as a minor determinant of the team's response. The Adidas Innovation Team (AIT) designed the ecosystem as a multi-sided platform enabling interactions between users and differentiated the miCoach Pacer in the market with an exclusive feature. Both of these design decisions arose from AIT's interpretation of user needs, and then its interpretation of the related information economics concepts. Evidence does not support that AIT considered a penetration pricing strategy. AIT considered but did not pursue expanding the number of user types in the ecosystem to feature outside companies and their complementary services, which could have spurred cross-side network effects. Given this evidence, Information Economics was a minor determinant of the team's response.

Similar to the Suunto T6 and Garmin Forerunner 50 ecosystems, the miCoach Pacer ecosystem was designed as a multisided platform enabling interactions between users and between users and non-users. Users could interact with one another on the miCoach web site and share their activity data with non-miCoach users on Facebook. As with the earlier cases, this design decision could be supporting evidence of the Information Economics hypotheses. The decision was made based on the team's interpretation of the relative importance of user needs.

The Adidas miCoach Pacer ecosystem distributed a unique form of information to users: audio-based coaching instructions. Both this information and its means of distribution differentiated the miCoach Pacer in the market, as no other competing fitness technology offered such a feature to users. The team's decision to include audio-based coaching instructions can be considered supporting evidence for the Information Economics hypothesis, however that design decision arose from the team's interpretation of the relative importance of user needs. Similar to the Suunto T6 team, AIT identified this differentiating feature based on its interactions with users early in the concept stage. This evidence supports the User Needs hypothesis as the stronger determinant of the team's response over the Information Economics hypothesis.

AIT considered an ecosystem design similar to the Garmin's Forerunner 50 design, which if implemented could have spurred cross-side network effects. During the concept phase

AIT identified that allowing outside companies to create complementary services with users' data could create value for users, Adidas, and those outside companies. Evidence does not support that the design idea arose from AIT's interpretation of the relative importance of user needs, rather its interpretation of the relative importance of information economics concept of cross-side network effects. AIT opted against the decision, citing their lack of budget and technical knowledge. AIT was also uncertain about the long term vision of the miCoach Pacer. Had AIT opted to design the ecosystem to feature these outside companies' complementary services, Information Economics would have been a stronger determinant of the team's response.

Evidence does not support that AIT pursued a penetration pricing strategy for the miCoach Pacer. AIT did not consider the price of the miCoach Pacer during its concept or development phases. Only when the miCoach Pacer was turned over to another team in the company to bring it to market did Adidas consider its price. While that other team's pricing strategy is unclear, evidence supports that the device was priced at the lower end relative to other fitness technologies. That lower price may very well reflect a penetration pricing strategy, or the other team's assessment that since the user needed to supply their own audio player, it should be priced as such. Given this lack of evidence, the Information Economics hypothesis' concept of penetration pricing should not be considered a determinant of the team's response.

In summary, AIT's interpretation of the relative importance of information economics concepts was a minor determinant of the team's response to its uncertainty. AIT designed the ecosystem as a multisided platform fostering same-side network effects amongst users and chose to differentiate the miCoach Pacer with its audio-based coaching instructions. Both design decisions arose from the team's interpretation of the relative importance of user needs. The team considered but opted against designing the ecosystem to foster cross-side network effects. Evidence does not support that the team pursued a penetration pricing strategy.

Summary

Evidence amongst the three cases offers mixed support for the Information Economics hypothesis as the key determinant of the teams' responses to their uncertainty. Information Economics was a key determinant of the Garmin team's response. The Garmin ecosystem design reflects the team's penetration pricing strategy and limited efforts to spur cross-side network effects with outside companies' complementary services. Information Economics was a minor determinant of the Suunto and Adidas teams' responses to their uncertainty. Both teams' interpretation of the relative importance of user needs led them to design their respective ecosystems as multisided platforms, as well as to differentiate their instrumented fitness experience in the market. Given the three cases' evidence, Information Economics should be considered a minor determinant of the teams' responses.

8.6 Conclusion

Evidence from the three cases supports the User Needs hypothesis as the key determinant of the three product teams' responses to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences. The teams interacted with users inside and outside the product teams to identify their needs, then used their interpretation of those needs to guide their responses to their uncertainty. Those needs varied amongst the two types of users teams targeted for their instrumented fitness experiences: early adopter and early majority users. Teams' interpretation of the relative importance of these two types of users' needs impacted what and how data was collected in the ecosystems, and what and how data and information was distributed and to whom, and the creation of value in the ecosystems.

Evidence does not support Regulations as a key determinant of the teams' responses to their uncertainty. While all three product teams consulted regulations regarding the collection and use of personal data, only Adidas slightly modified their ecosystem design based on those regulations. Suunto and Garmin's ecosystem designs are noted for surpassing regulatory requirements regarding providing users access to their collected data. These design characteristics arose from the teams' interpretation of the relative importance of user needs. Given this evidence, Regulations was not a determinant of the teams' responses to their uncertainty.

Evidence does not support that teams' interpretation of the relative importance of their expertise was a key determinant of their responses to their uncertainty. Teams' decisions to fulfill user needs led them to assess their expertise regarding fulfilling those needs. Teams turned to outside companies for their expertise fulfilling those needs, particularly with respect to collecting data and distributing information to users. Each team pursued an Acquiring strategy, where it paid a licensing fee to the outside companies with the needed expertise. In Garmin's case it acquired two companies outright. This evidence supports the User Needs hypothesis as the key determinant of the teams' responses, with Team Expertise a minor determinant.

Information Economics was a key determinant of the Garmin team's response and a minor determinant of the Suunto and Adidas team responses. The Garmin product team's interpretation of the relative importance of the information economics concept penetration pricing led it to design an ecosystem that prioritized offering a low priced instrumented fitness experience over fulfilling user needs for mapped route information. The Garmin team also responded by designing the ecosystem to spur cross-side network effects by permitting outside companies to access users' data to create complementary services. The Garmin team's interpretation of the relative importance of other user needs, particularly regarding importing and exporting data, offer supporting evidence for User Needs as a shared key determinant of its response. Suunto and Adidas' interpretation of the relative importance of user needs led the teams to design their ecosystems as a multisided platforms with differentiating features. This evidence further supports the User Needs hypothesis as the key determinant of the teams' responses to their uncertainty.

Evidence supports that User Needs was the key determinant of the three teams' responses

to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences. Garmin's interpretation of the relative importance of information economics concepts was a shared key determinant, while for Suunto and Adidas it was a minor determinant. Teams' interpretations of the relative importance of their expertise and regulations were minor and non-determinants, respectively. The next chapter examines the implication of these findings on future product teams' responses to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences.

Chapter 9

Conclusion

9.1 Introduction

This dissertation examined pioneering product teams' strategies regarding designing the data ecosystems for the instrumented fitness experiences under conditions of radical uncertainty, where the future is unknown and cannot be known. For these teams this radical uncertainty stemmed from multiple, related uncertainties: uncertainty regarding collecting new forms of personal data, analyzing that data and returning it to users as useful information, and individuals' acceptance of such data collection and use. My task in this dissertation was to identify and explain teams' differing strategic responses to this radical uncertainty.

Product teams responded in varying ways to their uncertainty. The responses varied with regard to what and how data was collected and analyzed, and what and how data and information was distributed and to whom. The responses further varied with respect to how they created value and for whom in the ecosystems. This dissertation explained where those differences came from.

For the three product teams featured in this dissertation, the teams' interpretation of the relative importance of user needs was the key determinant of their responses to that uncertainty. The teams' interpretations of the relative importance of information economics concepts and their own expertise were minor determinants of their response, while the teams' interpretation of the relative importance of regulations was not a determinant. These findings pose implications for product teams' responses to their uncertainty regarding designing the data ecosystems for future instrumented fitness experiences.

Future product teams will continue to be uncertain regarding designing the data ecosystems for their instrumented fitness experiences. This uncertainty stems from the emergence of new forms of collectable personal and particularly physiological data, such as brain waves. As earlier, teams are uncertain regarding the reliable collection and analysis of this data, and how to convert it into useful information for users. The volume of collectable data continues to expand, posing storage and analysis challenges. Social norms regarding the collection and use of personal data continue to evolve, as well as the breadth and scope of regulations

throughout the world.

This concluding chapter focuses on the relationships between these findings and future instrumented fitness experiences. Product teams' responses to their uncertainty will evolve as user needs evolve. New regulations, particularly in large consumer markets such as the European Union and United States, may result in teams' interpretation of the relative importance of those regulations being more determinant of their responses. Teams' responses offer insights into the dynamics and terms of their instrumented fitness experiences' social license. These findings may help product teams address stagnation in the contemporary instrumented fitness experience market.

As with case-based research, these findings apply to product teams' uncertainty regarding designing the data ecosystems for their instrumented fitness experiences. The findings may generalize to like phenomena, such as teams' responses to their uncertainty regarding designing ecosystems for instrumented experiences in other domains. Other researchers may test these findings in other domains, or extract new hypotheses from these findings for assessment in those domains. The vast range of potential domains presents researchers with numerous opportunities to make contributions.

9.2 Evolving User Needs

As user needs evolve in the instrumented fitness experience domain, so too will teams' responses to their uncertainty regarding designing the data ecosystems for those experiences. Just as in the cases, teams' interpretation of the relative importance of these user needs will impact the ecosystem designs, including how and where they create value. These evolving user needs may emerge from existing lead and early adopter users. Future teams' interpretation of the relative importance of these user needs will impact their responses in different ways.

Lead and early adopters in the cases exhibited a collection of shared needs of note. Suunto and Garmin's lead and early adopters sought the ability to import and analyze their existing fitness activity, and the ability to export their collected activity data for their own analysis and to share with friends and coaches. The teams' interpretation of the relative importance of these needs were key determinants of their response to their uncertainty. Each modified the collection and distribution aspects of their ecosystem designs to fulfill these needs by allowing users to import and export their data, respectively. The teams' decisions created value for users through fulfilling their needs. Allowing users to export their data also created value for companies offering competing instrumented fitness experiences, as those companies could then design their ecosystems to import that data.

While lead and early adopter users at the time needed access to their data, evidence does not support that those users also needed access to the analysis aspect of the data ecosystems. That is, lead and early adopters did not express a need to know how algorithms analyzed their data, whether by the instrumented fitness experience provider or an outside company. An algorithm is a set of rules that are used to calculate or process data. Each case's data

ecosystem analysis aspect featured algorithms that converted users' collected personal data into information, such as calories and heart rate.

Suunto's users did not cite that they needed to know how Firstbeat Technologies converted their collected data into its' EPOC and training effect information. Nor did users express a need to be able to modify how their data was analyzed in the ecosystem, such as adjusting calorie calculations. The teams did not design their ecosystems to offer users insight into this analysis, though Suunto communicated the presence of Firstbeat's analysis to users. The teams did not allow users to modify the ecosystems' analysis, though Suunto and Garmin allowed users to download their data for their own analysis. The teams did not field nor fulfill users' needs for insights into the algorithms used to analyze their collected data. Those needs may soon emerge, impacting future teams' responses to their uncertainty.

Recall that lead users are noted for exhibiting user needs that will later become widespread in the marketplace. (von Hippel 1986) Imagine a scenario where these users express the need to know how their collected data is analyzed and converted into information, as well as by whom. These lead users will need insights regarding and access to the algorithms collecting and analyzing their data in these future instrumented fitness experiences. This is not an unrealistic scenario, as there is unease amongst the public regarding the role of algorithms analyzing personal data.

Pasquale describes the emergence of these algorithms in our everyday lives. (Pasquale 2015) He calls this the rise of a black box society, where algorithms are hidden within information-mediated services such as search engines, social networking sites, credit scoring, and other services that collect and analyze personal data. These algorithms impact users' experiences with these services, such as the search results, advertisements, and financing offers they are shown. Pasquale argues that the lack of knowledge and transparency regarding these algorithms negatively impacts users, and proposes legal-oriented strategies to resist this algorithmic black box society.

Pew Research Center's study of personal data algorithms in society reveals unease amongst the public. (Rainie and Anderson 2017) In a survey of experts and the public, over one-third of respondents predicted that the overall impact of personal data algorithms will be negative for individuals and society, while a quarter predicted the impact will be 50-50, positive-negative. The study cited the need for increasing users' algorithmic literacy, which is their understanding of how personal data is analyzed and by whom. The report called for increased transparency into the presence, use, and workings of personal data algorithms, and legal oversight into their use.

Lead users may drive this call for algorithmic transparency for instrumented fitness experiences. Future product teams' interpretation of the relative importance of this user need will be a determinant of their response to their uncertainty. Teams may interpret this need and its importance in different ways, leading to varied data ecosystem designs that create value in different ways.

On one end of the spectrum, teams may opt not to fulfill this user need and not reveal any aspects of data analysis in the ecosystem. Recall how Garmin revealed little about how it analyzed users' data to calculate calories or heart rate zones. Such a response did and would

not create value for users, who may then opt to use another comparably more transparent instrumented fitness experience.

Teams may opt to fulfill this need by providing users with information regarding the role of such algorithms, such as Suunto did by revealing Firstbeat Technologies' role creating the T6's training effect and EPOC information. This response created more value than the prior response, as users were more informed and the outside company garnered positive attention or further business.

Alternatively, teams may opt to disclose the inner workings of such algorithms and allow users to modify the algorithms. This response would create comparably the most value for users, though not without ramifications for value created in and by the ecosystem. Teams may be reluctant to reveal their analysis processes. As a participant in the study that led to this research conveyed, such analysis is their "secret sauce." Revealing or broadening access to this analysis may jeopardize the ecosystem's ability to create exclusive value for itself, as competitors may adopt similar methods. For a product team that considers itself not expert providing such analysis, it may have to increase the financial compensation it offers an outside company who is willing to provide such transparent and modifiable analysis.

While it is unclear which of these responses future product teams may pursue, we can reasonably speculate that those teams willing to pursue more transparent and user-oriented value creation strategies may best attract lead and early adopter users to their instrumented fitness experiences. Product teams with already-released instrumented fitness experiences and user bases may be reluctant to pursue such strategies, given the risk of potentially allocating value to competitors. These product teams' beliefs regarding the best way to create value for their ecosystems may not adapt to this new information, presenting an opportunity for competitors.

Upstart product teams may believe that the best way to create value with their ecosystem design is through championing such transparency throughout their ecosystem design, particularly in a maturing marketplace. These instrumented fitness experiences may better appeal to lead and early adopter users by offering users the ability to import and export their data in a readable format, as well as a means to view and modify the algorithms analyzing their collected data. Upstarts could also open the analysis aspect of their ecosystem to outside companies who could create complementary analysis services for users. Upstarts may pursue such a strategy if they perceive they are not expert regarding such analysis, or if they see it creating a multisided platform. The design would spur cross-side network effects between these outside companies and users. These teams' designs may then be better positioned to create more value relative to their risk-averse competitors.

9.3 Emergence of New Regulations

Teams' interpretation of the relative importance of regulations was not found to be a determinant of their responses to their uncertainty. All three teams consulted European Union regulations regarding the collection and use of personal data. The teams' interpretation

of the relative importance of those regulations minimally impacted the designs of their respective ecosystems and how those ecosystems created value. Given the emergence of new regulations in large consumer markets such as the European Union, future teams' interpretation of the relative importance of regulations may be more determinant of their responses. These teams' ensuing data ecosystem designs may allocate value in comparably different ways and scales than in the three cases.

In 2016 members of the European Union agreed to replace Directive 95/46/EC, which as described in Chapter 2: Guiding Concepts regulates companies' collection and use of European Union users' personal data. The need to replace Directive 95/46/EC arose from member countries' concerns regarding rapid technological developments, growing globalization, and fragmented implementation of the regulations amongst member countries.¹ The European Union's new General Data Protection Regulation (GDPR) provides a single, enforceable law that applies to any company processing European Union residents' personal data, even if the company is based outside the European Union.² GDPR goes into effect in May 2018. GDPR varies from Directive 95/46/EC in two ways that may contribute to future product teams' interpretation of the relative importance of regulations being more determinant of their response than found in this study.

GDPR's right to access stipulates that companies must provide users with a means to easily access their collected data in an electronic format at no cost. Companies must also communicate to users "the logic involved in any automatic personal data processing," which can be reasonably interpreted as information regarding how algorithms analyze users' collected data. GDPR's related right to portability requires companies provide users with their collected personal data in a structured, interoperable, commonly used electronic format. GDPR does not specify the format, such as the comma-separated value (CSV) format. Users must be able to view their personal data in the file and import the electronic file into other companies' personal data systems.

Future product teams' interpretation of the relative importance of these regulations may play a more prominent role in determining their response to their uncertainty. At the extreme, product teams may respond by designing their data ecosystem to not collect personal data from European Union users. These teams may be concerned that providing users such easy access to their data lowers users' switching costs to competing experiences. Teams may be reluctant to communicate to users how they analyze collected data due to competitive concerns. Teams' response to their uncertainty would manifest as preventing European Union users from joining or using their instrumented fitness experiences. Teams' interpreta-

¹Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions: 'A comprehensive approach on personal data protection in the European Union,' COM (2010) 609 final. http://ec.europa.eu/justice/news/consulting_public/0006/com.2010.609_en.pdf

²Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32016R0679>

tion of the relative importance of these regulations would prevent the creation of value for these users, as well as the ensuing creation of value for teams themselves through offering the experience.

Alternatively, future product teams may respond by designing their data ecosystem to first and foremost fulfill GDPR requirements. Regulations may call for a data ecosystem design that does not necessarily fulfill user needs. Future users may not cite the need to readily download their collected data, such as in the Adidas case. Unlike the Adidas case the product team would need to fulfill this requirement. This response would allocate value to users, even though they had not cited this access as needed.

Product teams' interpretation of the relative importance of regulations may not be a key determinant for those teams who opt to surpass regulatory requirements. Recall from the Suunto and Garmin cases how both teams provided users with a means to download their collected data, even though it lowered users' switching costs to competing systems and there were no regulatory requirements. Future product teams may respond to their uncertainty with a similar strategy, but one focused on the data analysis aspect of their ecosystem designs.

Revisiting the earlier-cited potential future lead user need, users may need more information regarding and access to the analysis of their data than GDPR stipulates. Teams may opt to fulfill this need by not only communicating to users how their data is analyzed, but providing users with a means to modify that analysis. Such means are not required by GDPR. The key determinant of such a response would be the teams' interpretation of the relative importance of user needs, and the response would create more value for users than required by regulations. The response would create value for competitors, who may be able to glean insights for analysis in their own data ecosystem.

The future may hold that teams' interpretation of the relative importance of regulations such as GDPR is more determinant of their responses to their uncertainty than found in the three cases. This prominence may coincide with the emergence of new instrumented fitness experiences in the immediate period leading up to and following GSPR's introduction in May 2018. During this time teams may look to these regulations first to address their uncertainty in order to better ensure their instrumented fitness experience complies with said regulations. Teams may then turn to their interpretations of the relative importance of user needs, their own experience, and information economics concepts to fill the figurative gaps in their ecosystem designs. Product teams with existing instrumented fitness experiences will consult GDPR and modify their ecosystem designs to ensure compliance. Such modification may provide users with additional value by easing their access to their collected data. In effect, GDPR reallocates and creates new value in existing instrumented fitness experiences, with much of that value going to users. New instrumented fitness experiences' data ecosystem designs will also allocate comparably more value to users than pre-GDPR and non-compliant designs. Future teams' responses to their uncertainty may be more determined by their interpretation of the relative importance of GDPR than the teams featured in the cases.

9.4 Social License Dynamics and Terms

Anticipating future product teams' responses to their uncertainty offers insight into their instrumented fitness experiences' social license dynamics and terms. As noted in Chapter 2: Guiding Concepts, social license constitutes the demands of stakeholders who are affected by a company's activities. (Gunningham, Kagan, and Thornton 2003) Companies secure social license for their activities through engaging with stakeholders to identify the terms by which they must operate and then fulfilling those terms.

Stakeholders may include users, regulators, other companies, and potentially non-users impacted by companies' activities. A social license term is an agreement to fulfill a stakeholder need, not unlike this study's concept of a user need. Their definitions differ in that companies must fulfill social license terms in order to operate, while companies may operate without fulfilling all user needs.

Social license terms relate to how companies' operations create value and for whom. In exchange for permission to operate a company provides something of value in return. For instrumented fitness experiences, that value may take many forms. For example, Suunto and Adidas provided users with actionable fitness information, while Suunto and Garmin provided users with a means to download their data. That value may also take the form of a pledge not to perform an activity stakeholders deem harmful.

Teams' responses to their uncertainty can reveal much about their instrumented fitness experiences' social license: who the stakeholders are, their roles and requested terms, and if, what, and how teams fulfill those terms. We can anticipate future instrumented fitness experiences' social license by speculating how product teams will respond to their uncertainty regarding designing their ecosystems. The determinants of their response are indicative of certain social license characteristics.

Suunto secured its social license through engaging with users, other companies, and regulators to elicit their terms and then designing its ecosystem to fulfill those terms. Each of these parties were stakeholders whose terms impacted the creation and allocation of value to themselves and others in the ecosystem. Users expressed needs that the team then interpreted to guide their response regarding designing the ecosystem. User needs served as one bundle of social license terms. In return for collecting and analyzing users' data, users needed Suunto to provide them with actionable information to improve their fitness, a means to import and export data themselves, and the ability to share their data with others.

The Suunto product team turned to Firstbeat Technologies and Dynastream International to help fulfill these user terms. The companies expressed their own terms to Suunto, which manifest in the data ecosystem design allocating monetary value to the companies. Suunto's consultation of European Union regulations served as a proxy for engaging with regulators. In order to offer its instrumented fitness experience, the team would have to fulfill regulators' terms as detailed in the regulations. For example, regulations stipulated that the company could not distribute users' data to other companies without consent. The team already fulfilled and in several cases surpassed those regulatory terms by its prior decision to fulfill users' terms. It is unclear from the case evidence if the product team engaged with

non-users who could have been impacted by the T6's collection and use of personal data.

The Garmin product team secured its social license through a similar process of engaging with stakeholders, including users, other companies, and regulators. Evidence does not indicate that the team engaged with non-users. Garmin's key terms for securing that social license from users included providing users a means to import and export data themselves, the ability to share their data with others, and the ability to share their collected data with other companies' complementary services. The team turned to Dynastream International and MotionBased Technologies to help fulfill these and other user terms, but acquired the two companies rather than allocate them ecosystem value for fulfilling those terms. Though unclear from the case evidence, the product team also likely engaged with outside companies who would create complementary services with users' collected data. It is unclear what if any terms those companies presented to the team, or the team's response. As with the Suunto team, the Garmin product team consulted regulations but found its fulfillment of users' terms also fulfilled regulators' terms.

The Adidas team likewise secured its social license by engaging with the same types of stakeholders. Its social license terms differed in that they primarily related to providing users with actionable information to improve their fitness in a unique audio format and means to share their data with others. In return for collecting users' data, Adidas must create value for users by fulfilling these terms. Unlike Suunto and Garmin, its terms did not include providing users with a means to import or export their data. The team turned to Athletes' Performance International to fulfill the actionable information term, and Dynastream International to fulfill other terms. In both instances Adidas allocated monetary value to the companies for helping fulfill these terms. The team consulted and minimally modified its ecosystem design based on regulators' required terms. As with the other cases, the team's fulfillment of user terms surpassed regulatory terms. Evidence does not support that the team engaged with non-user stakeholders regarding their terms.

Future product teams' responses to their uncertainty will evolve as instrumented fitness experiences evolve. New forms of personal data may be collected from an ever-increasing range and types of sensors. Collected data will be analyzed with new algorithms to create new forms of information. Data and information will be distributed in more and more ways, including audio, video, and touch. Each of these technological developments present new ways to create value. As described earlier in this chapter, user needs and regulations will evolve and impact value creation as well. This evolution will impact future instrumented fitness experiences' social license, including the breadth of stakeholders and the prominence of their terms in securing that social license.

If we speculate that the key determinant of future product teams' response to their uncertainty continues to be their interpretation of the relative importance of user needs, we can anticipate that the social license for their instrumented fitness experiences will resemble those of the cases. Teams will principally engage with user-stakeholders to identify their needs and design their data ecosystem to fulfill those needs. These needs will serve as figurative social license terms: in order for the team to collect data it must provide users with something of value in return. In such a scenario instrumented fitness experiences' social

license terms will closely parallel user needs.

Alternatively we may speculate that teams' interpretation of the relative importance of regulations will be more determinant of their responses, particularly with the introduction of GDPR in the European Union. In such a scenario social license terms may closely mirror regulatory requirements. Teams may engage less with user-stakeholders to assess their terms, instead pursuing a strategy of relying on GDPR and other regulations as a proxy for users' terms. Such a strategy poses the risk of overlooking user terms which are not yet codified in those regulations, particularly the terms of lead and early adopter users. Should regulations stipulate that teams cannot share collected data with other companies, the role of those companies as social license stakeholders may be reduced. If teams' interpretation of the relative importance of regulations is more determinant of their responses to their uncertainty, these regulatory terms will have a more prominent impact on their instrumented fitness experiences' social license.

Future teams' interpretation of the relative importance of their own expertise may be more determinant of their responses, particularly as the technical complexity and breadth of user needs expand. Teams may increasingly deem themselves not expert and turn to outside companies for assistance, broadening the pool of social license stakeholders to include those companies. Those stakeholders may pose additional terms, such as monetary compensation and access to users' collected data. These terms may conflict with users' social license terms, potentially leading to a dilemma for product teams regarding whose needs and terms they should fulfill in order to create value and secure social license. In this scenario these other companies' terms may play a prominent role in instrumented fitness experiences' social license.

Lastly, teams' interpretation of the relative importance of information economics concepts may be more determinant of their responses. Given the rise and continued prominence of multisided platforms such as Airbnb, Uber, and Facebook, teams may principally focus on designing their data ecosystems to spur cross-side network effects amongst different types of users. In such a scenario the team would engage with two types of stakeholders: users and other companies offering complementary services to those users. Each stakeholder group would pose terms that the team must fulfill in order to secure social license. As with the expertise scenario, these outside companies may impose terms that conflict with users' terms. The product team will need to balance these terms in order to secure its social license and to create value. If teams' interpretation of the relative importance of the information economics concept multisided platforms is more determinant of their response to their uncertainty, the social license for the instrumented fitness experience will more prominently feature terms specified by companies offering those complementary services.

Future product teams' responses to their uncertainty regarding designing their ecosystems will vary, just as the responses of the teams in this study varied. Likewise the social license for each team's instrumented fitness experience varied, and much can be understood regarding the terms of that social license and its stakeholders by analyzing teams' responses. While we may not know how future teams will respond to their uncertainty, hypothesizing regarding the strength of each of this study's four determinants in shaping their responses offers insights

into the dynamics and terms of their instrumented fitness experiences' social license.

9.5 Conclusion

This dissertation examined how three product teams at the forefront of instrumented fitness experiences' emergence responded to their uncertainty regarding designing the data ecosystems underlying those experiences. Each team responded in different ways, creating a unique configuration of what and how users' personal data was collected and analyzed in the ecosystem, and what and how information was distributed and to whom. Their responses varied regarding the creation of value within those ecosystems, with some designs creating comparably more value in different aspects of the designs. Product teams' interpretation of the relative importance of user needs was the key determinant of their responses to their uncertainty, while their interpretation of the relative importance of regulations was non-determinant. Teams' interpretations of the relative importance of information economics concepts and their own expertise were minor determinants.

While the instrumented fitness experience market experienced rapid growth during the timeframe studied in this dissertation (2004-2010) and into 2015, at the time of this study the market finds itself stagnant. User adoption is less than forecast, if not slowing.^{3,4,5} One-third to half of tracker-type instrumented fitness experience users abandon their devices within six months.^{6,7,8,9} Studies return mixed evidence regarding instrumented fitness experiences' positive long-term impact on users' fitness. (Harris et al. 2015; Shuger et al. 2011) What might explain this stagnation?

Product teams have not yet identified the best ways to design the data ecosystems for their instrumented fitness experiences. Stagnation may be explained by teams' misinterpretation of user needs. As the market matures it would appear users' needs are not fulfilled, perhaps indicating that teams' responses create value for lead and early adopters but not the current

³Pressman, Aaron. "Sales of Wearable Smart Devices Can't Meet the Hype." *Fortune*. December 20, 2016. <http://fortune.com/2016/12/20/wearable-apple-watch-fitbit-hype/>

⁴IDC Research, Inc. "Worldwide Quarterly Wearable Device Tracker." http://www.idc.com/tracker/showproductinfo.jsp?prod_id=962

⁵IDC Research, Inc. "Fitness Trackers in the Lead as Wearables Market Grows 3.1 in the Third Quarter, According to IDC." December 5, 2016. <http://www.businesswire.com/news/home/20161205005301/en/Fitness-Trackers-Lead-Wearables-Market-Grows-3.1>

⁶Gartner, Inc. "Gartner Survey Shows Wearable Devices Need to Be More Useful." December 7, 2016. <http://www.gartner.com/newsroom/id/3537117>

⁷Arthur, Charles. "Wearables: one-third of consumers abandoning devices." *The Guardian*. April 1, 2014. <https://www.theguardian.com/technology/2014/apr/01/wearables-consumers-abandoning-devices-galaxy-gear>

⁸Gandhi, Malay. "Deconstructing the Fitbit IPO and S-1." *Rock Health*. May 11, 2015. <https://rockhealth.com/deconstructing-fitbit-s-1/>

⁹Maddox, Terry. "Wearables have a dirty little secret: 50% of users lose interest." *TechRepublic*. February 13, 2014. <http://www.techrepublic.com/article/wearables-have-a-dirty-little-secret-most-people-lose-interest/>

market's early majority users. Product teams may less understand or be misinterpreting early majority users' needs, leading to designs that do not return value to these users.

Contemporary instrumented fitness experiences by Fitbit, Garmin, and others are designed as multisided platforms connecting users with myriad companies offering those users complementary application-type services. These apps promise to provide users with new metrics and visualizations of their collected data. Product teams may be misinterpreting how to design their ecosystems as multisided platforms that spur cross-side network effects. The service-oriented sides of the platforms are crowded with offerings, potentially contributing to negative cross-side network effects. Users may face too many choices while also being uncertain of their own needs. Once adopted these services may not be meeting user needs, further contributing to abandonment. This market stagnation may be explained in part by teams' misinterpretation and poorly executed pursuit of cross-side network effects.

Product teams may be encountering a lack of expertise needed to create the data ecosystem designs they envision. Teams may assess they do not have the expertise to design data ecosystems that create unique and new value, and are unable to find that expertise in other companies. That external expertise may be in short supply or not yet exist. Product teams may be expert in similar ways and without means to tap additional expertise, contributing to a stagnation of innovation that limits the market's growth.

Teams' interpretation of the relative importance of regulations may play a role in this stagnation, as they may be reluctant to fulfill users' need for certain information. For example, rather than returning the number of steps taken in a day, users may desire more personalized, forward-looking prescriptive recommendations based on their collected data. Such information may create more value for users and reduce user abandonment, however it may classify an instrumented fitness experience as a medical device. In the United States medical devices are subject to stricter technical and safety requirements by the United States Food and Drug Administration. Teams' interpretation of the relative importance of these regulations may be stifling their perceived ability to provide users with this more valuable information, contributing to market stagnation.

Findings from this dissertation may help product teams better understand how to respond to their uncertainty regarding designing the data ecosystems for their instrumented fitness experiences. Teams can assess the impact of the four determinants – their interpretations of the relative importance of user needs, regulations, information economics concepts, and their own expertise – on their responses. Through such assessment teams may identify opportunities and means to create new and unique value with their ecosystem designs.

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Appendix A

Appendix

A.1 Interview Guide

1. Describe your role at the company (at the time of creating the technology).
2. What was your title?
3. What were your primary responsibilities?
4. How long had you held those responsibilities?
5. Describe the (name of instrumented fitness experience) development team. How big was it? What were the roles? Where were members located?
6. Describe the marketplace conditions at the time. Who were your competitors?
7. Why did you develop the (name of instrumented fitness experience)?
8. How did you decide what data about users the (name of instrumented fitness experience) would collect?
9. Was there any other data that you wanted to collect? What was it? Why?
10. Before launch, how did you engage with users about the (name of instrumented fitness experience), whether publicly or privately?
11. Were there certain aspects (of the product) you wanted to engage with users about?
12. Were there certain aspects you didn't want to engage with users about?
13. Before launch, how did you engage with third parties about the (name of instrumented fitness experience), whether publicly or privately?
14. Were there certain aspects you wanted to engage with third parties about?

15. Were there certain aspects you didn't want to engage with third parties about?
16. How did you engage with users post-launch, whether publicly or privately?
17. Post-launch, were there certain aspects you wanted to engage with users about? What were they? Why?
18. Post-launch, were there certain aspects you didn't want to engage with users about? What were they? Why?
19. How did you engage with third parties post-launch, whether publicly or privately?
20. Post-launch, were there certain aspects you wanted to engage with third parties about? What were they? Why?
21. Post-launch, were there certain aspects you didn't want to engage with third parties about? What were they? Why?
22. Is there anything else you think I should know that I didn't ask? That we didn't discuss?
23. Who else do you think I should speak with that would offer a valuable perspective?
24. Would you be willing to introduce me to that person?
25. Following our conversation I'll transcribe and review our conversation, and may have a couple of clarifying questions. If so, may I pose them to you?

A.2 Codebook Excerpts

Table A.1: First Round Descriptive Codes

Code Category	Code
Interviewee	Role
	Title
	Responsibilities
	Time in Role
Company	Primary Location
	Size
	Public / Private
Development Team	Size
	Locations
Public Artifacts	User Manual
	Privacy Policy
	Press Release
	Regulations
	API Documentation
	Customer Support Forum

Table A.2: Second Round Provisional Codes

Start List Source	Code Category	Sub-Category / Code	Code
Interview Guide	Background	IFE Team Description IFE Market Conditions IFE Competitors Responsibilities Duration Interviewee Title Interviewee Role IFE Target Users	
	Pre-Launch Phase	Reason to Develop IFE What User Data to Collect Engage with Users Engage with Third Parties	Wanted to Engage Not Engage Wanted to Engage Not Engage
	Post-Launch Phase	Engage with Users Engage with Third Parties	Wanted to Engage Not Engage Wanted to Engage Not Engage
	Closing	Anything I Didn't Ask Anyone Else to Interview	
Exploratory Study	IFE Model Component	Data Collection Collected Data Data Analysis Information Returned	
	Opportunities Challenges	Use Data in Organization Technical Organizational Philosophy Social License Use Data in Organization	Collection Conveyance Analysis Empowerment Control
Development	Idea Genesis Requirements Gathering Technical Development Quality Assurance Beta Release Release Day Post-Release		
Eisenmann Framework	Stakeholder Interaction	Users Non-Users	Supply-Side Regulators Providers Sponsors Suppliers

Table A.3: Third Round In Vivo Codes

Code Category	Sub-Category / Code	Code
Motivation to Interact With	Users	Understand Needs Quality Assurance Convert from Disgruntled to Evangelist Improve IFE
	Non-Users	National Culture Address Technical Challenges Become More Powerful
Culture	National Development Team Organization	
Philosophy	Closed	As Business Opportunity Manifests in Business Decisions Manifests in Development Effort Opposition to Third Party Interaction Risks
	Open	As Business Opportunity Manifests in Business Decisions Manifests in Development Effort Manifests in Product