Is Open Always Better? - A Taxonomy-based Analysis of Platform Ecosystems for Fitness Trackers

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Abstract. The wearable fitness technology sector is growing steadily as a result of the increasing miniaturization of sensors and the rapid rise of the mobile internet. In this context the use of fitness trackers promises the consumer the provision of personalized health services. This additional value cannot be achieved by a single company but is realized by a multitude of different actors that collectively create value within platform ecosystems. In order to understand their structure and properties and get a current market overview, a taxonomy to analyze wearable fitness technology platform ecosystems is developed following the methodology by Nickerson et al. [1]. The empirical-to-conceptual approach is conducted by applying the flagship fitness tracker of the ten highest rated manufacturers as a fundamental platform technology. Using the taxonomy four clusters could be identified that primarily distinguish the fitness tracker companies regarding their openness to consumers and developers.

Keywords: Fitness tracker, wearable fitness technology, platform ecosystem

1 Introduction

Fitness tracker offer the potential to provide personalized and ubiquitous health services to consumers [2]. Through their numerous sensors and functions, they enable and empower users to track and change their habits to lead a healthier lifestyle. This can be either done for private application by using an app to analyze the recorded health data or in context with medical treatment where the physician receives the collected health data to improve the care of the patient. Global market revenue for fitness applications and wearables is estimated to be $ 9.6 million by 2021 [3] with a total number of 581.23 million users [4]. At this the greatest interest of consumers is in the area of wrist-worn fitness wearables with integrated sensors and medical devices that enable the transmission of health data [5]. The wearable fitness technology market is composed of different manufacturers and third party suppliers which creates interdependencies within the value chain on the one hand but also causes divergent requirements for transmission standards and operating system compatibility on the other hand. The market will continue to grow further which opens up a high potential in the wearable fitness technology sector and offers the actors involved the opportunity to contribute to

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an improvement in digital health care [6]. Often, the consumer is in the focus, whose use is to be enhanced by the application of fitness trackers and health apps in a prosperous ecosystem.

To understand the necessary activities a company needs to perform in order to create value, usually the underlying business model is analyzed. In the case of fitness trackers, the business model approach cannot be limited to the value creation of one individual company. Instead, the shared but distributed creation of value must be captured within a platform ecosystem and its complementors.

In the literature there are numerous models for business model analysis, such as the frequently used business model canvas [7], but these primarily consider the value that is added within a company or by cross-company collaboration, but do not take into account the specific characteristics of the wearable fitness technology sector. Here, platform-specific aspects [8] as well as special features of business ecosystems [9, 10] have to be integrated into the analysis. To the best of our knowledge no taxonomy could be identified in the scientific literature, that also includes both platform and ecosystem aspects in connection with the wearable fitness technology sector.

2 Theoretical Background

In this work fitness trackers serve as a practical example to analyze platform ecosystems. The term wearable fitness technology is thereby understood as applications which are related to the healthcare sector while they are operated on mobile devices such as wearables, smartphones or tablets [6]. This enables and empowers the consumer to care about personal health independently by overcoming geographical, temporal and organizational boundaries [11].

2.1 Platform Ecosystem

Platform ecosystems change the way competition takes place on the market. This implies that the most successful company is not inevitably the manufacturer of the best technological product but rather the holder of a superior platform strategy that is part of a prosperous ecosystem [12]. To be precise this means a set of actors whose interaction takes place based on a technological platform which results in a number of application and service solutions [13]. New networks are created which do not only comprise different business units of a single company, but rather involve multiple business units of external companies as well. Consequently, the consideration of the entire ecosystem including external entities is necessary to guarantee superior business performance. These external entities or third party suppliers are called complementors and offer products or services that are based on the platform technology and increase its value [12]. In this context the existence of a common platform technology is essential to enable successful cooperation between different entities [14].

The platform architecture influences the degree of collaboration within the ecosystem and the design of the technological basis affects how well the surroundings respond to the platform [8]. If a company wants to make its platform technology prevalent within the industry the technology must be open to complementors.

Furthermore, incentives for companies to join the associated ecosystem need to be given [12]. On the one hand, this openness is defined by the property rights of the platform technology and on the other hand by the possibility to use, modify, extend and spread these platform assets [15]. In this context, the concept of network effects explains how an increased user base enhances platform attractiveness for developers, leading to an increased offering of products and services which in turn stimulates user growth [12].

Once the consumer joined the platform, there can be barriers and switching costs which lock the consumer in due to the incompatibility of the platform technology [16]. This can be intended by the platform leader to bind the consumer to the technology and keep him inside the provided ecosystem. Another way to control the platform ecosystem lies in the management of boundary resources [17]. In digital ecosystems these are often represented by Application Programming Interfaces and Software Development Kits which are the tools that enable developers to create complementing applications. Thereby the design of boundary resources is a difficult decision for the platform leader between motivating external developers to enter the platform and retain platform control [18]. This also refers to the feature of digital innovation in platform ecosystems and the concept of generativity which is defined as the platform's ability to generate change that was not anticipated and is caused by the contribution of a wide and diversified audience whose actions are not filtered [19].

2.2 Fitness Tracker

The easiest and prevalent way for consumers to track their personal fitness level and health condition is by using fitness trackers. They help to collect, track and monitor health data which enables private users to prevent health problems and integrate a healthy lifestyle into their daily routine [20]. In this work a fitness tracker is defined as wrist-worn wearable fitness technology that uses integrated sensors to collect health data of the carrier [21]. The wearable device itself is complemented by a companion application that makes it develop its full functionality by synchronizing the data to the smartphone and performing aggregation and analysis activities as well as showing the health data history. For this reason, the mobile application is also part of the analyses. The fitness tracker is the first contact point of the consumer who wants to track fitness and activity data and make use of personalized health services. For this reason, it defines the technological basis of further integration possibilities with additional products and services as well as interaction activities with other users or medical professionals.

3 Research Methodology

The purpose of this taxonomy is to contribute to scientists' understanding of wearable fitness technology platform ecosystems. The conducted analysis is coming from a fitness tracker point of view, which builds the starting point of the interaction from the consumer with the ecosystem. From a one-dimensional perspective, in which only the classification of a single fitness tracker model is considered, the taxonomy serves to get an overview of the surrounding ecosystem of a fitness tracker and which value is offered to the consumer, from the wearable manufacturing company itself as well as from the complementary ecosystem. A multi-dimensional perspective, in which the classification of different fitness wearable manufactures is compared to each other, helps to analyze the current market situation and to determine different structures and strategies of wearable fitness technology platform ecosystems.

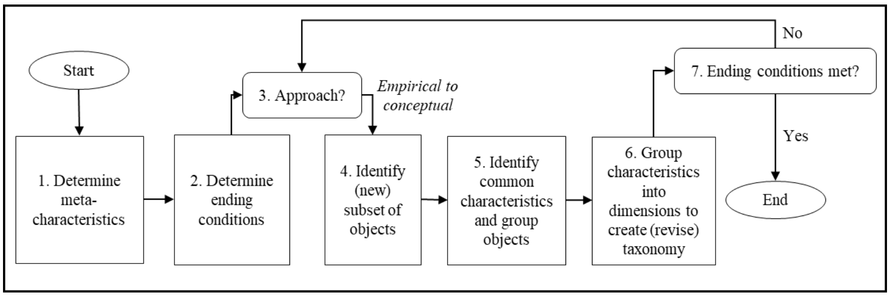

Figure 1. Methodology for taxonomy development [1]

The process of taxonomy development thereby follows the methodology defined by Nickerson et al. [1], who developed a method that is especially suited for taxonomy development in information systems. Based on the aforementioned purpose of the taxonomy, the features of fitness trackers concerning technology and services build up the meta characteristics of the taxonomy. The ending condition is set by the objective that a representative sample of objects has been examined. The approach that is followed is empirical-to-conceptual because a lot of data about fitness trackers is available. The subset for this approach is defined of the ten highest rated fitness trackers. These are the most successful wearable technology devices on the market for which a lot of detailed information is accessible. Having reviewed this representative sample of fitness trackers, the ending condition of the taxonomy development process is met.

The systematic sample of the fitness tracker sector was conducted by combining the market and consumer point of view. To do so the market share of wearable fitness technology manufacturers from the first quarter 2017 was taken as a basis [22] and complemented by the first ten results of a Google search for the term “fitness tracker rating 2017” where magazines, fitness bloggers or consumers evaluate fitness trackers regarding their functionality. The selection was made on basis of the manufacturing company and not on the foundation of single fitness tracker models. For every (single and multiple) fitness tracker model reference in one of the reviews each manufacturer obtained one point on the consumer side. The manufacturer with the highest market share obtained ten points, the second highest nine points, etc. on the market side. So in each category ten points maximum could be reached. Finally, the ten highest assessed manufacturers were selected. Subsequently the official website or web shop of the manufacturer was used to identify the flagship fitness tracker of the company which means the device with the highest range of functionality and a price limit of 400€ so it still comes within the field of the average health-oriented consumer who is not professionally obliged to track fitness and activity data. Furthermore, we assume that the flagship fitness tracker includes the same functionality and more than the models with a lower range of functionality do. Figure 2 illustrates the sample of the ten highest rated manufacturers as well as their identified flagship fitness trackers.

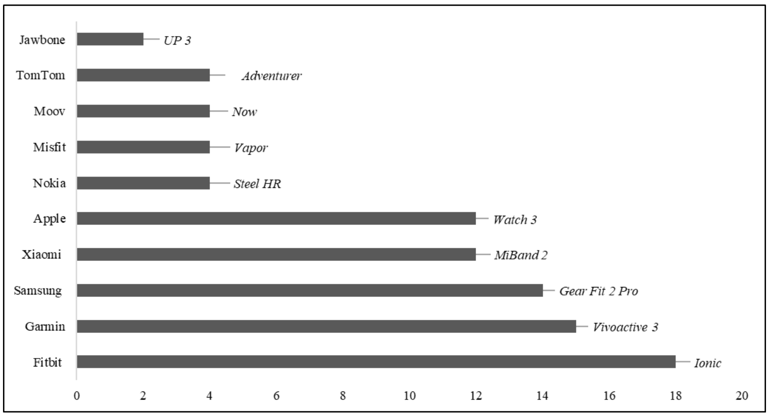

Figure 2. Rating of fitness tracker manufacturers and choice of fitness tracker model

The next step in an inductive taxonomy development process, is the analysis of these empirical cases to define common characteristics which are matching the predefined meta characteristics. To do so the flagship fitness tracker model was analyzed in an online research process which was conducted during September 2017. The evaluated data is publicly available and comes from a variety of online sources which comprise the manufacturer website, user guide, privacy policy, technology and fitness blogs, fitness tracker tests, video reviews, press articles, developer guidelines and the test of the fitness tracker companion app itself. Sources that comprise official information from the manufacturer were preferred to e.g. fitness blogs which may be subjectively biased by the author. Only if the services and functions are officially supported by the manufacturer they are taken into account for the data collection. For each fitness tracker model the meta characteristics were collected and thereby common characteristics of the objects were identified. Following the selected set of characteristics was grouped into dimensions which were each considered to be mutually exclusive and collectively exhaustive [1].

Subsequently the established framework for analyzing the layered modular architecture of digital technology created by Yoo et al. [23] is used to further classify the derived dimensions. The framework serves to analyze the new organizing logic of digital innovation and thereby focuses on product innovation, which means that a novel good is produced by combining physical and digital elements in a new and yet unknown way. The new combination has to be based on digitization and make the firm reconsider existing structures regarding its organization and information technology. Fitness tracker fulfil these given requirements and thereby meet the criteria to be defined as a digital innovation. For this reason, the layered modular architecture of digital technology is taken as a further classification of the derived taxonomy dimensions for platform ecosystems in the field of wearable fitness technology. Additionally, we distinguish between platform and ecosystem characteristics. The resulting taxonomy is displayed in Table 1. The dimensions colored in dark and mid grey represent the categories that were adopted from Yoo et al. [23].

Table 1. Taxonomy for the analysis of platform ecosystems for fitness trackers

Dimension		Platform sub dimension	Platform characteristics	Ecosystem sub dimension	Ecosystem characteristics
Device layer	Logical capability	**Native operating system**	*Available* *Unavailable*	**Mobile operating system**	*iOS* *Android* *Windows Mobile*
				Stationary operating system	*MacOS* *Windows* *Linux* *Browser*
	Physical machinery	**Display technology**	*Digital colour display* *Digital monochrome display* *Analog display* *No display*	**External accessories**	*Health accessory (blood pressure sensor, sleep sensor, scale)*
		Service life	*1-3 days* *3 - 7 days* *1-2 weeks* *more than 2 weeks*		*Lifestyle acccessory (smart button, lights, intelligent personal assistant)*
		Water resistance	*Available* *Unavailable*		
		Integrated sensors	*Optical heart rate sensor* *Bioimpedance sensor* *Accelerometer (linear acceleration)* *Gyroscope (angular acceleration)* *Magnetometer/compass* *GPS sensor* *Altitude sensor/altimeter/barometer* *Temperature sensor* *Ambient light sensor* *SpO2 sensor* *Capacitive sensor*		*Music accessory (bluetooth headhpones, bluetooth speaker)*
		Interaction functionality	*Microphone* *Vibration motor* *Voice feedback* *Haptic feedback/taptic engine*		*Sports accessory (cadence sensor, heart rate chest strap)*
		Proprietary technologies	*Available* *Unavailable*		*Fashionable accessory (jewelry straps, necklaces)*
		Internal music storage	*Available* *Unavailable*		
		Accessories	*Health accessory (blood pressure sensor, sleep sensor, scale)* *Lifestyle acccessory (smart lights, intelligent personal assistant)* *Music accessory (bluetooth headhpones, bluetooth speaker)* *Sports accessory (cadence sensor, heart rate chest strap)* *Fashionable accessory (jewelry straps, necklaces)* *Pet accessory (smart collars)*		*Pet accessory (smart collars)*
		Storage duration of health data on device	*1-3 days* *3 - 7 days* *1-2 weeks* *More than 2 weeks*		
Transmission layer		**Transmission standard**	*Cellular (LTE/UMTS)* *Bluetooth (BLE/Smart)* *WiFi* *NFC* *ANT/ANT+*	**Transmission standard**	*Cellular (LTE/UMTS)* *Bluetooth (BLE/Smart)* *WiFi* *NFC* *ANT/ANT+*
Service layer		***Customer***		***Developer (private)***	
		Native application	*Available* *Unavailable*	**Application Programming Interface**	*Available* *Unavailable*
		App store for native apps	*Available* *Unavailable*	**Software Developmet Kit**	*Available* *Unavailable*
		Mobile application	*Distributed functionality* *Central functionality*	**Native app programming language/standard**	*JavaScript* *Java* *Swift 4* *HTML5* *CSS/SVG*
		Application functionality	*Basic functionality (display of health data)* *Medium functionality (consolidation and aggregation of health data)* *High functionality (interpretation of health data and additional services)*	**Tutorials and documentation**	*Available* *Unavailable*
		Smartphone notifications	*Available* *Unavailable*	**Developer community**	*Available* *Unavailable*
				External company (corporate)	
				External application	*Competing functionality* *Complementary functionality*
Contents layer		**Memory location of user data**	*Offline - local storage* *Online - cloud storage*	**Integration of external databases/app data**	*Available* *Unavailable*
		Data export	*Available* *Unavailable*		

4 Findings

The dimensions and characteristics of the derived taxonomy serve to categorize different wearable fitness technology platform ecosystems and therefore show the differences in properties from which strategies of companies can be inferred. But while building the dimensions of the taxonomy some characteristics occurred to be identical for all fitness trackers, their companion app or the complementing ecosystem. These are not part of the final taxonomy because they cannot be used to distinguish between companies though still provide an indication which characteristics are taken as basic prerequisites in the wearable fitness technology sector.

4.1 Market findings – Similarities

The first similarity is noticed in the field of user data collection and data security. There is a necessity to create a user account to use the fitness tracker and application. Also the activities of data usage and data collection which are conducted on the personal data associated to the user account as well as on anonymous data (according to the privacy policy of the company) are very similar among the evaluated manufacturers. All companies offer or enforce to store the health data in the cloud. There is no company that guarantees the server location for data storage is in Germany, which means data protection laws from different countries, mostly America, can apply.

The second characteristic all ecosystems have in common is the integration of Social Media services as well as the offering of additional community or blog services. Usually the companion app offers the function to post personal activity or workout data by an in-app button on Facebook or Twitter. Also every company offers a community or blog function where users can interact with each other or get additional information regarding fitness, health or technology related topics.

The third similarity is the untethered transmission of health data. Obviously all fitness trackers in the wearable fitness technology sector offer wireless transmission from the device itself to a smartphone or tablet. The transmission standard that is used on every device and thereby represents the norm is Bluetooth, in most cases in the version Bluetooth Low Energy/Bluetooth Smart.

4.2 Clustering the Market based on Distinctive Characteristics

The final taxonomy was completed for every manufacturer to derive clusters of wearable fitness technology platform ecosystems. For this purpose, a consolidation of the sub dimensions in which the wearable fitness technology platform ecosystems differ noticeably was conducted. Figure 3 shows the aggregated sub dimensions and the aggregation logic to derive cluster archetypes. Based on this, Figure 4 depicts the resulting clusters. These consider two main dimensions, *openness to consumer* and *openness to developer*. That is, because the success of a platform highly depends on its surrounding ecosystem [24] which is defined by external companies that need to be incentivized to create complementing products and services [12]. There are two different strategies to open the platform: (1) open-up the market and grant access to the platform to reach further consumer segments or (2) give up control of the platform itself [25].

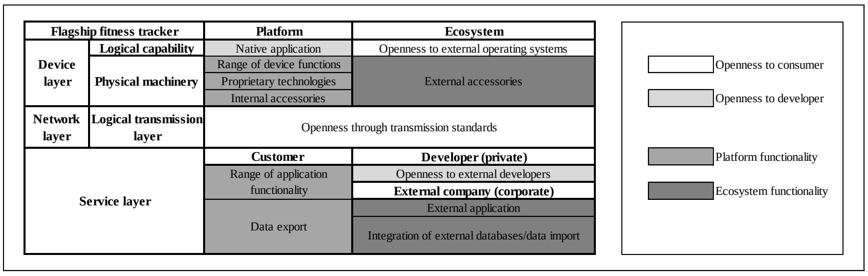

Figure 3. Aggregated taxonomy to derive platform ecosystem clusters

The first cluster dimension, *openness to consumer*, shows the interoperability with external operating systems and transmission standards which determine the way and by whom fitness trackers and their companion application can be used and thereby shows how open the market is. Wearable fitness technology platform ecosystems that are very open to consumers can be used without any prerequisite regarding operating system or transmission standard and are positioned on the right side of the cluster. Those that are closed are depicted on the left side of the cluster and impose some technological and software requirements which makes them just available for a limited audience.

Second, *openness to developer* is defined by opening the possibility for developers to program native and mobile applications complementing the fitness tracker and its application's functionality. In connection with this there is a native operating system, native and mobile app store [24], native programming language as well as API and SDK. For this reason, independent and external developers are able to program applications that natively run on the fitness tracker itself and use its collected sensor data so the platform owner partly gives up control. Companies that offer many possibilities for external developers to design complementing applications are located at the top of the cluster, the ones that do not offer them at the bottom.

Additional to this dimensions, Figure 4 displays the range of functionality that is offered to the consumer through the platform itself and the surrounding ecosystem. For the platform point of view this means the range of functionality of the fitness tracker and the companion application, existence of proprietary technologies and internal accessory as well as the possibility to export the data. From the ecosystem perspective it is defined as the range of functionality of external accessory, the existence of complementary external applications as well as the possibility to integrate data from external databases or apps. The platform's own range of functionality is represented by the dark blue colored circuit. The ecosystem's range of functionality is depicted by the size of the light blue colored circuit. The overall size of both circuits together shows the range of functionality that the platform ecosystem as a whole offers to the consumer.

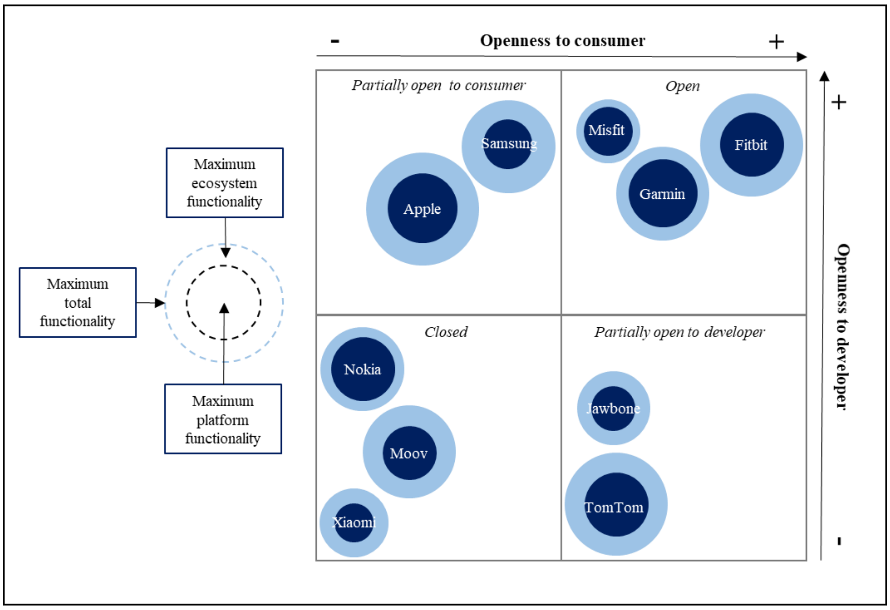

Figure 4. Four cluster of wearable fitness technology platform ecosystems

The first cluster is represented by Samsung and Apple. Their fitness trackers are surrounded by a large ecosystem and equipped with a native operating system but they only open their platform to complementary products and services that are based on their "own" mobile operating system which is iOS for Apple and Android for Samsung. Both companies are originally not located in the wearable fitness technology sector and therefore could be influenced by their already established ecosystem that they try to expand further.

The second cluster encompasses Garmin, Fitbit and Misfit. All three company strategies follow the proposition for platform producers by Cusumano and Gawer [26] to not develop own complementary products if the capabilities to compete in this area are not present by designing the parts of the platform ecosystem themselves where they already own or gained special knowledge. Fitbit bought Pebble [27] a company that formerly designed smartwatches so they are able to introduce their own native operating system, Fitbit OS and thereby open up their platform even more to external developers. Misfit decided to equip its newest fitness tracker with Android Wear 2.0 and not a proprietary native operating system as planned earlier. By doing so Misfit is able to appropriate the value that is already existing and take advantage of the network effects [12] of the Android Wear developer community and native app store. Garmin originally comes from the navigation sector and derives benefit from existing knowledge in the area of positioning by offering detailed GPS and compass functionality as well as features like golf course maps.

The third cluster includes Jawbone and TomTom. Both companies are open to consumers by being interoperable with different external operating systems and transmission standards but are still closed for external developers only offering an API and some developer support.

Xiaomi, Moov and Nokia form the fourth cluster. All companies are not open to all popular operating systems nor do they offer native operating systems. While Xiaomi and Moov only offer one fitness tracker, which in case of Xiaomi is very limited in device functionality, Nokia still lacks in external accessory additionally to the own health and lifestyle accessory that was acquired from Withings [28].

5 Discussion

Applying the taxonomy, market findings could be derived that mainly support the theories in platform ecosystem literature. Basole and Karla examined the structure of mobile platform ecosystems and concluded that although many new platforms have emerged no dominant and market wide standard could be established [24]. In the wearable fitness technology sector some recurring and market wide patterns regarding transmission standards, user data management and social interaction functions could be identified but there is still a high fragmentation in the area of fitness trackers and applications themselves. Furthermore, the strategy of manufacturers highly differs in their degree of openness to consumers and developers.

The choice of clusters can be validated by looking at the range of functionality of the platform ecosystems. Based on the assumption that (1) the range of an ecosystem's functionality determines platform success [24] and (2) the more open a platform is designed the more complementing innovation is developed by its ecosystem [25], the most successful companies should be rated high for at least one dimension of openness. In this context successful companies are defined as those who offer a high range of total platform ecosystem functionality to their consumers. In Figure 4 this applies most of the time with the largest circuits being placed in the *open* or *partially open to consumer/developer* cluster. Outliers can be identified looking at Misfit and Jawbone. For Misfit the small ecosystem can be explained because they just opened their platform by using Android Wear 2.0 as a native operating system for their newest fitness tracker. The benefits of the network effects of the Android developer community still need to be realized to appropriate value in the future. Jawbone is open to all popular operating systems and offers an API as well as developer support but lacks in the functionality of the fitness tracker itself. Still the device does not have a display and is only equipped with three internal sensors. So the core architecture of the product itself is not developed which is necessary to become successful and attract innovative complementors [26].

6 Conclusion

To summarize, we proposed a taxonomy for the analysis of platform ecosystems for fitness trackers. It was derived using empirical data of the ten highest rated flagship fitness tracker models. The completed taxonomies show that while some similarities exist the market is still fragmented. Furthermore, we proposed a cluster that considers two main dimensions, *openness to consumer* and *openness to developer*. It displays that companies differ in their degree of openness and there is no prevalent market strategy. In addition, we rated the total range of functionality that is offered by the fitness tracker manufacturers. Relating this to the openness of the platform ecosystem we could observe that companies which are considered open in at least one dimension offer a higher range of functionality overall. Assuming that the range of functionality equates consumer benefit we propose that companies which pursue an open strategy are more successful.

The limitations of the study are the selection of manufacturing companies and fitness tracker models. Given our sample size of ten devices the wearable fitness technology market cannot be represented completely. The assignment of characteristics may be biased by subjective interpretation of the researcher.

Further research could increase the sample size of evaluated fitness trackers and number of coding researches. Additionally, the link of certain platform ecosystem structures to market performance indicators of the manufacturer could be addressed and success factors derived. In doing so some structures could be identified as more effective than others. Furthermore, there is the opportunity to include also accessory and complementing apps of a third, fourth, etc. tier. This would result in a large interrelated network of fitness products and applications and also show the cooperation and interrelation of the analyzed companies in-between each other.

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