Desirability of consumer internet of things products: how emerging businesses address consumer desires to improve user experiences

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Abstract: Developing desirable consumer IoT products becomes the challenge for emerging businesses. Lack of clear understanding about the functions and desirability of such products has led to a lower level of consumption than was expected. The purpose of this paper is to propose a value-based framework for product desirability, and to examine value propositions in terms of product value, product features, and user experiences by considering emerging businesses. Data from 982 companies was extracted from CrunchBase. Desired value factors, and product features companies seek the most to develop desirable products were identified. Functional value was offered more frequently than emotional value or social value. Safety, interactivity, and connectivity are the most significant features considered by companies. Companies should consider the emotional and social aspects alongside the focus given to functional aspects. The proposed framework, and the results obtained could be important for companies to develop desirable products addressing consumer preferences.

Keywords: consumer IoT; desirability; functions; features; design; value; user experience; CrunchBase.

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1 Introduction

With the forthcoming surge of connected devices like appliances, vehicles, sensors, and countless other things, Shin (2019) argued that the internet of things (IoT) represents the next generation of an intelligent information society. It is considered as one of the most disruptive technology (Baltuttis et al., 2022), and will be a major driver of product and service innovation (Cannizzaro et al., 2020). In terms of design and marketing, IoT products are a real revolution (Touzani et al., 2018) that has paved the way for devices with multiple functions (Mehra et al., 2022). Their ability to collect sensitive information about the environment, and disseminate it via the internet (Angelini et al., 2018), has the potential to drastically alter people's lives, work productivity and consumption patterns (Shin, 2017).

The technology company, Reply, defined the CIoT as "the billions of physical personal devices such as smartphones, wearables, fashion items and the growing number of smart home appliances, that are now connected to the internet, collecting and sharing data" (Mashal and Shuhaiber, 2019). If reference is given to product features, CIoT products can also be described as smart connected products resulted from the coupling of physical products and information-based digital services (Belingheri and Neirotti, 2019). These products collect data from the environment to deliver beneficial services to individuals (Padyab and Ståhlbröst, 2018), and make consumers' lives easier by allowing them to access these services at any time (Chouk and Mani, 2019). According to the European Commission (EC) sector inquiry report on consumer IoT, the sector is predicted to grow dramatically in the coming years as the use of such products becomes more commonplace in consumers' daily lives.

Even though the CIoT is a significant element of a global market with increasing market value, the research in the area specifically in emerging businesses is still in its early age. Emerging business in this context represents companies emerged due to the emergent of technologies such as IoT. Based on available research, it can be observed that:

1 most of the research in consumer IoT focused on measuring adoption levels or users' intention towards using these products (Lucia-Palacios and Pérez-López, 2021; Zhang et al., 2020), and considered value creation in the purchasing (pre-purchase, purchase and post-purchase) process (Bayer et al., 2020)

2 studies by scholars and practitioners thus far have mainly focused on the technical aspect of implementation (Angelini et al., 2018; Shin, 2019; Sorri et al., 2022; Zhang et al., 2020) ignoring emotional and social aspects

3 consumers have still not been convinced to purchase CIoT devices and applications (Meng et al., 2019)

4 consumers fear the introduction of additional technological complications to their lives (Touzani et al., 2018), and perceived risk (Hasan et al., 2021) are believed to be barriers to keep the adoption of such products low.

Many IoT solutions fall short of capturing a big market, staying niche items for professionals, due to functionality that does not appeal to the ordinary user, deployment methods, and interaction models that are difficult to use (Angelini et al., 2018). The failure to incorporate compelling values of the CIoT products might result undesirable products. For instance, smart home technologies have not been widely adopted by mainstream users (Coskun et al., 2018), which indicates that designers need to work to improve these goods. There are also products that completely failed to capture the market. Google Glass, Juciero, Amazon Fire Phone, Google Wave, and Blackberry Playbook are good examples. These products did not succeed because they ignored consumer preferences and instead only paid attention to technological advancements.

As a result, there is a need to investigate and analyse the value propositions that the CIoT companies provide to consumers. It is also important to investigate such value across different product categories using a holistic approach (desired value, product features and user experience). The purpose of this paper is to propose a value-based framework, and examine the value and functions offered by companies in terms of desired product value, product features, and user experiences by considering emerging businesses in the CIoT sector. More specifically, this paper aims to identify the main CIoT product value offerings, and critically considered product features for a better user experience. To address these purposes, two research questions were formulated:

RQ1 How do emerging businesses in consumer IoT develop products with better user experience?

RQ2 What product values are proposed by emerging companies in consumer IoT for targeted customers?

The first research question was addressed by undergoing a systematic literature review and developing a value-based framework whereas the second research question was addressed by analysing the data obtained from 982 emerging businesses in the CIoT sector registered in the CrunchBase platform.

This research is different from previously conducted studies in two ways. First, it applies a holistic approach that linked desired product value, product features, and user experiences to examine actual value creation process. Most of the research thus far focused on measuring adoption of such products considering value creation in the purchasing process. Even though studying adoption levels is important, it is also equally important to examine how companies could develop products with better user experience. Second, this paper introduces a comparison of value propositions across five different categories of the CIoT products (smart home devices, wearable devices, healthcare devices, connected vehicle devices and assistance devices). This research considered companies that are producing CIoT products in general rather than examining a single

use case. This created a room to make comparisons of value proposition differences across different product groups. The study can serve as a theoretical basis for subsequent research examining at consumer IoT in the actual value-creation process. This study proposed a value-based framework and identified the value proposition factors companies most need to focus on when creating products with compelling value propositions.

The current paper is organised as follow. Section 2 presents the literature review that describes the frameworks and theories in consumer IoT studies followed by the framework development. Section 3 present the research methodology adapted, details of data collection and analysis. Section 4 provides results of the data analysis. Section 5 provides discussion including the theoretical and managerial implications, and limitations and future research directions. Finally, Section 6 concludes the study.

2 Literature review and value-based framework development

Even though identifying the typical scenario faced by a user of the CIoT is often very complex (Angelini et al., 2018), many CIoT devices and applications are targeted at non-technical users who prioritise low cost and ease of operation. Designers should understand consumer expectations in order to create more effective and desirable goods for their target market (Mishra et al., 2015). In this aspect, digital technologies are increasingly being utilised to supplement physical products. By building the IoT into the architecture of products and supporting the development of new product features, the consumer's value proposition is increased (Belingheri and Neirotti, 2019).

2.1 The systematic literature review process

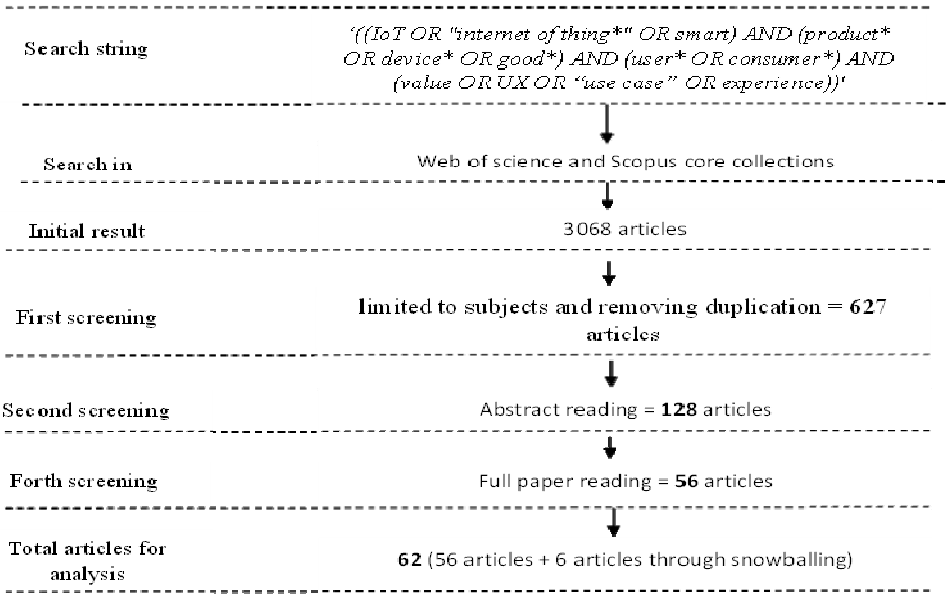
We conducted a systematic literature review to extract the available body of knowledge in consumer IoT study. We used the query '[(IoT OR "internet of thing*" OR smart) AND (product* OR device* OR good*) AND (user* OR consumer*) AND (value OR UX OR "use case" OR experience)]' to search articles. The Scopus and Web of Science core collection were used to search available resources. The search was limited through business and management, psychology, social science, ergonomics, and industrial engineering journals. After removing the duplication, 627 articles were collected. Further screening through abstract reading with some exclusion criteria minimised the result to 128 articles. Finally, a full paper reading with exclusion criteria made the number of papers for analysis to be 56. We also employed some snowballing to add six articles, and totally analysed 62 research articles. The selected papers were mapped based on authors' names, journal name, publication year, purposes, research questions, research methodologies, main constructs, contexts, and future research directions. Mapping articles helped us to understand the research in consumer IoT in detail, and to make analysis carefully. The article selection process is shown in Figure 1.

2.2 Theories and frameworks in consumer IoT

In consumer IoT study, different theories have been applied to examine the acceptance and adoption of such products. Several frameworks have been proposed by different researchers to examine value.

Based on a thorough analysis of the literature, four groups of frameworks in consumer IoT studies were observed. These are technology acceptance model (TAM) (Mehra et al., 2022; Chatterjee et al., 2021; Kaczorowska-Spychalska, 2019; Lin et al., 2017; Schill and Godefroit-Winkel, 2019), theory of planned behaviour (TPB)-based frameworks (Hossain et al., 2021; Mashal and Shuhaiber, 2019; Yang et al., 2017), product design-based frameworks (Ling et al., 2021; Coskun et al., 2018; Funk et al., 2018; Wang and Chen, 2018; Wang et al., 2018; Yang et al., 2019; Zheng et al., 2018), and theory of consumption value-based frameworks (Zhang et al., 2020, 2018). Table 1 illustrates some of the conceptual frameworks proposed in the consumer IoT studies.

Figure 1 Article selection process



Most of the research in consumer IoT focused on examining adoption levels and intention to use. Research should also focus on user-centred approaches to develop and design desirable products.

In this regard, there exist some design-driven approaches commonly applied in different product designs and new product development (NPD) processes. IDEO's design thinking approach (IDEO.org), quality function deployment (Wang et al., 2016), user-centred design innovation (Verganti, 2011), and design-driven innovation approach (Verganti, 2009) are some of them. However, applying these tools varies from company-to-company, and it did not stop product developers' emphasis to technical performance of products over the soft aspects (emotional and social value of a product). This research proposed a user-centred framework that emphasises the actual value creation process integrating desired product value, product features, and user experience. The framework will provide a room for product development and design to create better product value propositions.

Table 1 Summery of proposed frameworks in consumer IoT

Source	*Theory of consumption value-based*	*Product design-based*	*TAM-based*	*TPB-based*	*Focused on*
Mehra et al. (2022)			X		Factors affecting adoption of products
Chatterjee et al. (2021)			X		Organisational-internal environment on intention to adopt AI
Ling et al. (2021)	X	X			Product attributes and perceived value on purchase intention
Hossain et al. (2021)				X	Attitudes towards using wearables on intention to use
Frank et al. (2021)	X				Perceived product value on behavioural intent to adopt AI-based consumer products
Meng et al. (2019)	X				CIoT features and the effects on consumption experience
Ahmad et al. (2019)	X				Intentions to use CIoT
Shin (2019)	X	X			Attitude of consumers in using
McDermott et al. (2019)		X			Important CIoT features
Kaczorowska-Spychalska (2019)			X		Intention to use
Schill and Godefroit-Winkel (2019)			X		Intention to use
Mashal and Shuhaiber (2019)				X	Intention to buy
Pinochet et al. (2018)	X				CIoT features and the effects on consumption experience
Caputo et al. (2018)	X				Intentions to use CIoT
Lee and Shin (2018)	X				Perceived product smartness
Coskun et al. (2018)	X				IoT features and relate them with perceived value, user experience, satisfaction and loyalty
Wang and Chen (2018)	X				IoT features and relate them with perceived value, user experience, satisfaction and loyalty

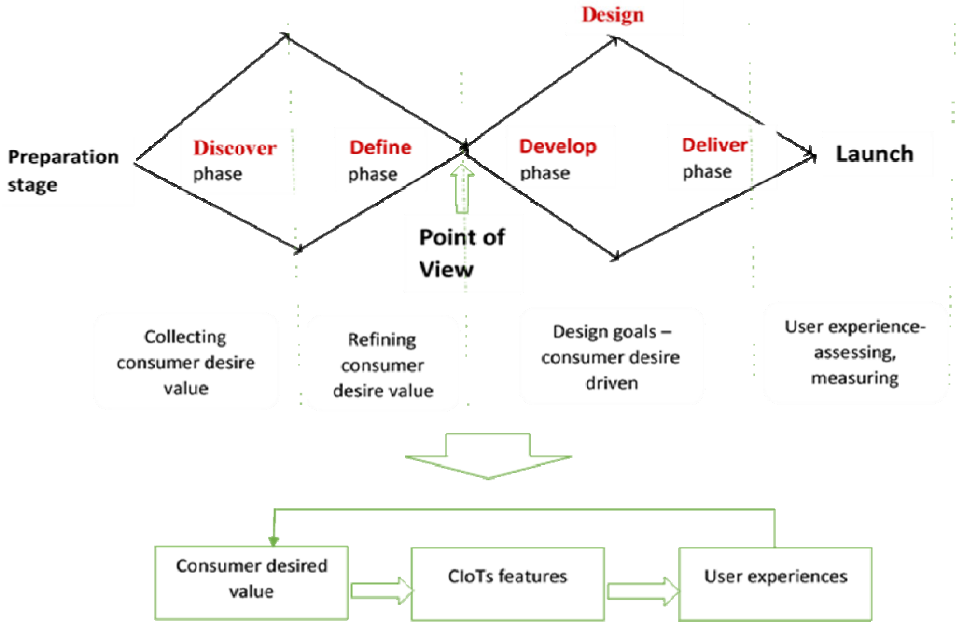
Table 1 Summery of proposed frameworks in consumer IoT (continued)

Source	*Theory of consumption value-based*	*Product design-based*	*TAM-based*	*TPB-based*	*Focused on*
Touzani et al. (2018)	X				Perceived value
Pinochet et al. (2018)	X				IoT features and relate them with perceived value, user experience, satisfaction and loyalty
Angelini et al. (2018)		X			Identifying properties
Coskun et al. (2018)		X			Important feature to satisfy customers' desires
Wang and Chen (2018)					Adoption
Yang et al. (2017)	X				Attitude of consumers in using such products
Yang et al. (2017)				X	Intention to use
Shin (2017)				X	Quality of experience
Lin et al. (2017)			X		Intention to resist
Yoon and Cho (2016)	X				IoT features and relate them with perceived value, user experience, satisfaction and loyalty
Jung et al. (2016)		X			Important feature to satisfy customers' desires
Yoon and Cho (2016)			X		Adoption
Kim and Lee (2016)				X	Resistance to use
Jin et al. (2013)			X		
Shin (2012)				X	Analysing usability of technology

2.3 Value-based framework development

A value-based framework was developed based on the integration of the theory of consumption value, and product design. By integrating theory of consumption value and product design, user-centred approach that will help companies to develop better value proposition was proposed. Desired value factors, product features, and user experience are at the centre of value creation process. Integrating these factors provides a holistic approach to examine the value propositions by companies and find a way for improvement. Even though desired value, product features, and user experience are the core process to create value, the relationship between them is usually confusing. To clear out this confusion, the design thinking concept was considered. Taking the concept of IDEO's double diamond model, it is possible to understand that desired value drives product feature, and product features enable better user experiences. The process is illustrated in Figure 2.

Figure 2 The process of creating the relationships of the main constructs (see online version for colours)



2.3.1 Desired value

Woodruff (1997) stated that "consumers may desire a certain value (desired value) and they may evaluate a product or service as they experience it (received value)." Based on consumer needs, Benamar et al. (2020) categorised value dimensions into three categories: product-related value, social-related value and personal-related value. Product-related value encompasses all the benefits that the consumer takes from the product's use and can be classified into two categories. The first is related to product function, and the second is related to the consumers' need for pleasure (emotional aspect). The product value related to function incorporates utilitarian value (functional

value) and convenience value (Davis, 1989). Functional value is described as one of the essential drivers for meeting consumers' needs and desires, and it is the primary purpose for the creation of a product (Ahmad et al., 2019). The functional value mainly refers to the quality/performance and product's price (Zhang et al., 2020). It also refers to how easy it is to use the products (Davis, 1989; Kim and Shin, 2015).

The product value related to a consumers' need for pleasure, is mainly referred to as the emotional value dimension (Caputo et al., 2018). It refers to the hedonic, control, and novelty aspects of CIoT products (Cengiz and Kirkbir, 2007), and is mainly related to the ability of a consumer to gain pleasure in using the product (Caputo et al., 2018; Mashal and Shuhaiber, 2019; Ling et al., 2021). The social value of a product is evaluated based on how well it can help a consumer to be accepted within a society, or on how well the product can be used to make a good impression on others (Benamar et al., 2020). The social value dimension refers to the social acceptance, trust, and networking functions of CIoT products (Benamar et al., 2020; Cengiz and Kirkbir, 2007; Jin et al., 2013; Zhang et al., 2020). In the proposed framework, the desired value was seen from functional, emotional, and social value dimension perspective with respective value factors.

2.3.2 CIoT product features

The other important factors in designing desirable CIoT devices and applications are the product features. In CIoT studies, some researchers refer to these as 'features' (Coskun et al., 2018; McDermott et al., 2019; Meng et al., 2019), while others used terms like 'attributes' (Pinochet et al., 2018; Shin, 2019; Touzani et al., 2018), or 'characteristics' (Meng et al., 2019; Shin, 2019; Wang and Chen, 2018). In this paper, the term 'CIoT feature' is defined as "the prominent attributes used to describe the characteristics or properties of products" (Cadden and Lueder, 2012). Identifying the appropriate and desired CIoT features will lead to the creation of products with better user experiences (Mishra et al., 2015). It is understood that the coupling of physical and digital products consumed by people with diversified skills and views, can create tension in research and design (Karlsson and Lovén, 2005). These tensions, if not properly managed, can impact design decisions in ways that might prevent the product from delivering its promised benefits (Belingheri and Neirotti, 2019). Hence, CIoT features are important elements for designing and developing desirable products. Shin (2019) used relative advantage, compatibility, complexity, trialability, and observability features to examine the acceptance of IoT products. Coskun et al. (2018) identified the following features as important design considerations for smart home appliances: the ability to be controlled remotely, cooperate, learn, be adaptable, be autonomous, provide guidance, offer human-like interaction, and have multi-functionality and upgradability. Some other researchers (e.g., Meng et al., 2019; Pinochet et al., 2018) proposed CIoT features that affect consumer experiences. However, most of these studies examined only the consumers' perspective. Based on the frequency of use in the literature, seven CIoT product features were identified. These are connectivity, interactivity, intelligence, safety, autonomy, adaptability and observability.

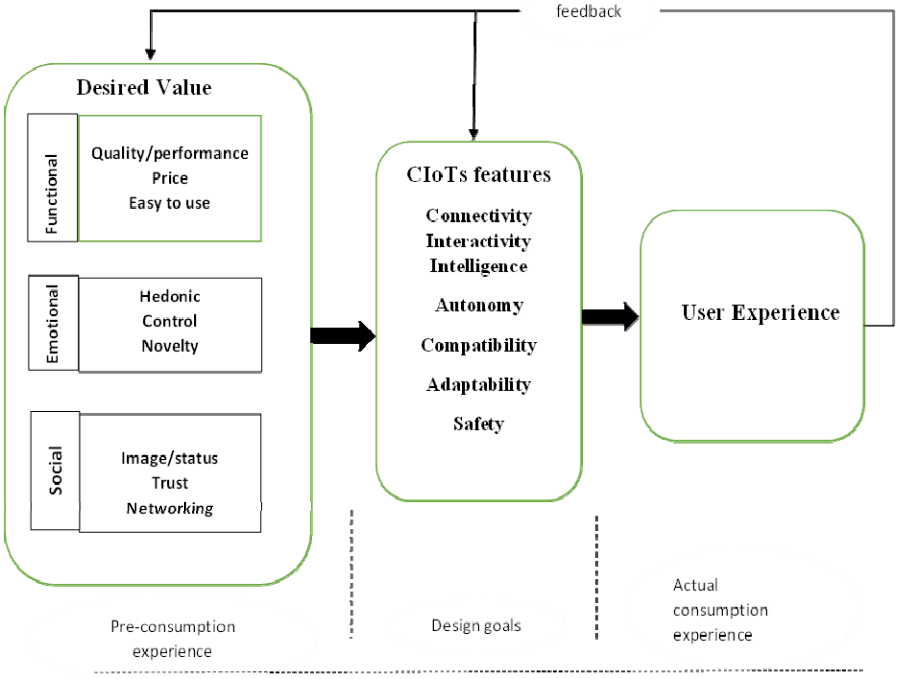
2.3.3 User experience

Recent trends have also shown that rather than focusing on the smart products themselves, marketers should concentrate on the kind of consumer experiences that are

likely to arise from users' interactions with products (Touzani et al., 2018). This means that instead of buying a platform or smart devices controlled by an algorithm, the consumer is opting for an experience (Touzani et al., 2018). The ISO 9241-210 definition of user experience stressed that "the design addresses the whole user experience and defined user experience as not only a consequence of the presentation, functionality, system performance, interactive behavior and assistive capabilities of an interactive system, both hardware and software, but a consequence of the user's prior experiences, attitudes, skills, habits and personality" (Wang et al., 2018).

This paper applies the consumption aspect of user experience as defined by Mishra et al. (2014), described as a consumer perception-based facets and utilities arising out of product use, without considering brand judgements. Some scholars used generic approaches to analyse user experience while others (e.g., Pucillo and Cascini, 2014; Sundar et al., 2014) decomposed user experience into its elemental levels. The proposed value-based framework is shown in Figure 3.

Figure 3 The value-based framework (see online version for colours)



The factors in the value-based framework are operationally defined as shown in Table 2.

The failure to incorporate functionalities (functional, emotional and social) of the CIoT products and weakness in targeting appropriate enabling features may make products undesirable. Because of functionalities that do not appeal to the ordinary user or deployment processes, and interaction models that are not easy to use, many IoT solutions fail to capture a large market, remaining niche goods for experts or professionals (Angelini et al., 2018). The question of 'how companies can respond to the current and future needs of consumers to deliver desirable products' is worth further investigation, particularly with reference to businesses in the CIoT sector.

Table 2 Definitions of factors in the framework

Factor	*Definition*	*Sources*
Quality/ performance	The utility derived from the perceived quality and expected performance of the product.	Cengiz and Kirkbir (2007), Rauschnabel et al. (2015), Zhang et al. (2020)
Price	The utility derived from the product due to the reduction of its perceived short-term and longer-term cost.	Cengiz and Kirkbir (2007), Zhang et al. (2020)
Easy-to-use	The degree to which a person believes that using a particular system would be free of effort.	Davis (1989), Shin (2015)
Hedonic	The feeling of fun, amusement, fantasy, arousal, sensory stimulation and enjoyment in using.	Rokonuzzaman et al. (2022), Hou et al. (2020), Zhang et al. (2020)
Novelty	Change from routine, escape, thrill, adventure, surprise and boredom alleviation.	Cengiz and Kirkbir (2007), Rauschnabel et al. (2015)
Control	The feeling of sense of control in using (things are done by the choices made by users).	Cengiz and Kirkbir (2007)
Image/status	The position reinforced by adoption and usage of innovation in a social context	Hou et al. (2020), Jin et al. (2013), Zhang et al. (2020)
Trust	Product/service providers have to be honest, dependable and reliable.	Yang et al. (2017)
Networking	The ability to sharing information with other people that allows for understanding its benefits.	Rauschnabel et al. (2015), Caputo et al. (2018)
Connectivity	The ability to connect to the internet and put the user in an environment that is both physical and virtual.	Shin (2019), Touzani et al. (2018)
Interactivity	The timely means of information communication between consumers and devices.	Pinochet et al. (2018), Shin (2019), Meng et al. (2019), Shin (2017)
Intelligence	The degree of automated functions, according to the operation of the IoT product. It is the ability performs complex configurations by itself and does not require complex reasoning process.	Pinochet et al. (2018)
Autonomy	The ability to operate in an independent and goal-directed way without interference of the user.	Lee and Shin (2018), Rokonuzzaman et al. (2022)
Adaptability	The ability to improve the match between its functioning and its environment.	Lee and Shin (2018)
Observability/ sense of presence	The ability of the product to be observed when needed, and sensation of quit real communication in using.	Pinochet et al. (2018), Shin (2019)
Safety	The degree to which damage can be avoided, which can be applied to any vulnerable and valuable assets.	Klobas et al. (2019), Chang et al. (2014)

3 Research methodology

To examine the value propositions emerging businesses are proposing, the qualitative data from emerging companies registered in the CrunchBase was employed. CrunchBase is a platform for business information of firms all over the world from early-stages to the market leaders (Bzhalava et al., 2022; Holicka and Vinodrai, 2022; Tunçalp and Yıldırım, 2022). This study mainly used CrunchBase as a source of data. There are alternative platforms to be used as data source such as Pitchbook, AVCJ and CB Insights (Ang et al., 2022), AngelList[1], Mattermark[2] and Tracxn[3]. For this research, CrunchBase was chosen due to:

1 CrunchBase has a wide range of information on start-ups, companies, and venture capital firms (Ang et al., 2022).

2 CrunchBase has a user-friendly interface that makes it easy to search for and find information on specific companies.

3 Crunchbase has advanced search capabilities that allow you to filter, sort, and segment the data according to specific criteria and parameters.

4 Crunchbase is widely used and recognised as a reliable source of information on start-ups and venture capital (Ferrati and Muffatto, 2020; Tunçalp and Yıldırım, 2022).

CrunchBase sources, updates, and validates data daily through four synergetic activities, making it a reliable data source (Ferrati and Muffatto, 2020; Schulte-Althoff et al., 2021). More than 4,500 global investment firms update their own profiles, which allow CrunchBase to access the most up-to-date data. Active users can submit information that is subjected to registration and social validation. This information is often reviewed by a moderator before being accepted and published. CrunchBase also uses artificial intelligence to verify the reliability of data, validate data accuracy, scan for anomalies, and provide alerts about data discrepancies. CrunchBase also validates the collected data through in-house data science teams. Due to the quantity and quality of collected data, CrunchBase is frequently used by academic researchers and practitioners (Ferrati and Muffatto, 2020; Tunçalp and Yıldırım, 2022). For these reasons, Crunchbase was chosen as a data source for this research.

To the broader list of emerging businesses in the consumer IoT, we used 'IoT' as a keyword to search in the platform. CrunchBase allows to filter, sort, and segments the data according to specific criteria and parameters. The prim data was filtered and sorted using parameters such as company names, primary role, home page, short-descriptions, extended-descriptions, category, city, country, status and founding time. Based on the information in the 'category', we further refine the data using consumer electronics, consumer devices, clothing and apparel, health and information technology.

To choose companies, the information in the short-descriptions, extended-descriptions, and home pages was carefully considered. Three basic criteria were used in the process:

1 companies producing end-application products

2 companies currently operating

3 companies updated their data in the CrunchBase recently were considered.

Table 3 A section of company name vs. value factors matrix

	Quality/performance									*Price*			*Easy-to-use*				
	Better	*Faster*	*Useful*	*Well made*	*Standard quality*	*Productive*	*Effective*	*Energy efficient*		*Reasonable price*	*Value for money*	*Economical*	*Easy to*	*Easy to control*	*Understandable*	*Flexible*	
hous.Me								x									
Ambiquemicro					x			x								x	
Rokoko.com										x							
ascentaerosystems.com			x	x			x						x				
workinman.com																	
inpixon.com						x				x							
clockworksanalytics.com	x							x					x				
zbliss.com																	
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For 982 companies																	

Note: Functional value as a sample.

The evaluation strategy was manual. The authors, by reading the information and based on the three criteria, selected the companies for this analysis. As a result, data from 982 companies were extracted for this analysis. The geographical distribution of companies indicated that 35.64% of companies are in the USA, 24.95% of companies are in Europe, 24.85% of companies are in Asia, and the rest are in Australia and Latin America.

The data relating to the type of products or services, product descriptions, functions, value propositions, value statements, strategies, and associated use cases were extracted. For this purpose, a checklist was developed based on the value-based framework. The checklist items related to functional value were adapted from several studies (Cengiz and Kirkbir, 2007; Davis, 1989; Hou et al., 2020; Rauschnabel et al., 2015; Zhang et al., 2020), while checklist items for emotional value were adapted from Cengiz and Kirkbir (2007), Hou et al. (2020), Rauschnabel et al. (2015) and Zhang et al. (2020). The checklist items related to social value were adapted from Hou et al. (2020), Jin et al. (2013), Rauschnabel et al. (2015), Yang et al. (2017) and Zhang et al. (2020). The items for the CIoT features were also adapted from Lee and Shin (2018), Pinochet et al. (2018) and Shin (2019), whereas the items related to user experience were adapted from Raptis et al. (2017) and Sundar et al. (2014).

A matrix with company names and product value factors was then developed. Using the matrix, it is possible to map which companies are considering which product values, features and targeted experiences. We mainly used product descriptions, value statements, and use cases sourced from short descriptions, extended descriptions, and companies' websites in the CrunchBase to develop the complete data mapping. Short descriptions give slight information about products, product use, and customers whereas extended descriptions are detail information about companies' value statements, strategies, products, technologies, customers, and the business in general. Table 3 shows the section of the matrix developed for the product value related to the CIoT product functional value. A complete matrix for all value factors with their respective items and 982 companies was developed to map the data. The example below shows how the qualitative data was sorted to fill Table 3. The following is a section of an extended description for Company A[4] in their words:

> "Company A improves a kettle's use, how we interact with it and it removes any unknowns associated with *controlling it remotely*. Company A provides a user with *real-time visual feedback* through the mobile app. Volume, temperature and time are all linked and visible in Company A. With these three variables included into the user feedback the following features are only possible through Company A:
>
> - *Smart scheduling – With volume sensing, Company A uniquely starts water heating before the time scheduled, ready for when you arrive.*
> - *Perfect tea brewing – Users can set temperatures with a simple slide and tap of their finger; notifications* are then linked to reaching this temperature. Cool-down cycles can be scheduled to boil and then cool to reach optimum drinking temperatures to create perfect tasting tea's.
> - Baby bottle – This feature allows parents using the app to check the water level, boil and then set a cool down temperature (e.g., 70°C) for the baby formula at a time to suit you. *It's that simple*.

- Volume and illumination link – With volume and illumination heat link, users on the app are able to see the water level in the kettle – if it's in use or being scheduled.
- *Share, discover and learn preferences*. With Company A's cloud system, we aim to open up a connected interface for sharing your favourite beverages and learning new ones.
- Much more… A smart home product is more than a *blind remote with alarms, it connects with all users*. We want to skip forward the smart home appliance category a couple of years and benefit more people, sooner, whilst not creating more wasteful, smart products."

In this description, we found that description related to *usefulness, simplicity, sensitive user needs, timely feedbacks, the ability to improve itself, and the ability to connect with all users*. These are similar discerptions with the checklist items for quality/performance, easy-to-use, interactivity, autonomy, and connectivity respectively in our proposed value-based framework. We went through the descriptions and find similar expressions to the checklist items developed for the value-based framework. In a similar way, we went through each companies' descriptions and fill Table 3 by sorting the qualitative data.

Descriptive statistics were used to analyse the data. Based on the matrix, the frequencies of individual, and cumulative value factors were analysed. Ultimately, the CIoT product value factors that companies emphasise were identified and prioritised. The main features companies considered when developing such products were also identified and prioritised. The user experiences that, companies are trying to respond to with the level of depth were also explored. Knowing that specific categories of CIoT products might have different considerations, a comparison was made that looked at different categories of products. For this purpose, five product categories were used. These categories were chosen because a significant number of companies are manufacturing them. Smart home devices, wearable devices, assistance devices, healthcare devices, and connected vehicles were the categories used for comparison.

4 Results

The CIoT product values, features, and targeted user experiences were analysed. First, the product values (functional, emotional and social) offered by companies were analysed by taking the total sample. Then, a comparison of such value across different categories was analysed. A similar approach (i.e., the first analysis was made for the total sample, and then comparisons employed across categories) was used for CIoT features, and user experiences. Smart home devices, wearable devices, healthcare devices, connected vehicles, and assistance devices were the categories used in this analysis. Other categories (communication devices, fitness devices and tracking devices) were not considered because they were represented by a small number of companies.

4.1 Consumer IoT product value

Among the three product value dimensions, companies most often emphasised functional aspects. As shown in Figure 4, companies emphasised functional value (77.16%) more than emotional value (20.45%) and social value (2.38%).

Figure 4 The level of offerings of the three value dimensions (see online version for colours)

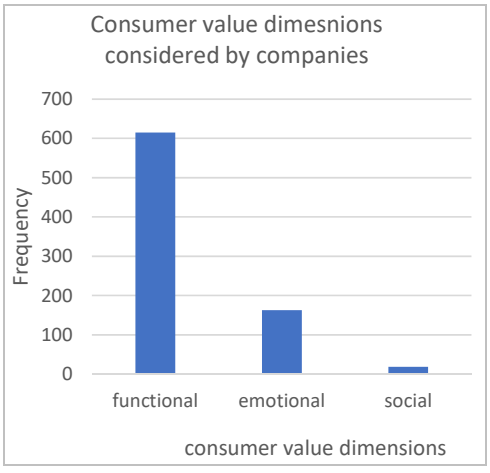


Table 4 Summary of CIoT product value offerings by companies based on the total sample

Dimensions	*Consumer value factors*	*Specific offerings*
Functional value (77.16%)	Quality/performance (45.69%)	Better performance (49.82%)
		Energy efficient (16.73%)
		Usefulness (12.81%)
	Easy to use (36.58%)	Easy to learn/operate (52.00%)
		Understandability (23.11%)
		Flexibility (14.67%)
	Price (17.72%)	Reasonable price (61.47%)
		Economical (39.45%)
Emotional value (20.45%)	Hedonic (70.55%)	Artistic (34.78%)
		Enjoyable (18.26%)
		Relaxing (36.52%)
	Control (15.95%)	Easy in control (95.45%)
	Novelty (13.50%)	Original (81.81%)
Social value (2.21%)	Trust (73.68%)	Reliability (92.85%)
	Networking (26.32%)	Communicating with others (83.33%)

As can be seen in Figure 5, quality/performance (32.75%), and easy-to-use (26.22%) were the two functional values that the companies offered most frequently to consumers. The functional value of price was also important for companies, reflected in 12.70% of company descriptions. The price aspect in this context represents the way companies are trying to make product prices reasonable and economical in response to user desires. Therefore, for the functional aspect of product value, companies are focusing on delivering products that have a better performance/quality, are easy to use, and have a reasonable price. For the emotional value aspects, the hedonic value of products (13.04%) was considered more often than control and novelty, which had frequencies of 3.03% and 2.56%, respectively. The social value dimension of product value is somewhat

represented by trust (1.63%), which mainly focuses on the reliability of the interaction and communication between users and CIoT products. Looking at the two most offered functionalities (quality/performance and easy-to-use), specific offerings have been identified. Accordingly, the three most important functions in the quality/performance factor were better performance, energy efficiency and usefulness. In the easy-to-use aspect of product value, easy to operate/learn was the most important factor. Flexibility, understandability, and ease of control were also factors that were often described for the easy-to-use aspect. The results of the product functionalities with their respective specific offerings are shown in Table 4.

To identify whether the product value offerings differ across the various CIoT product categories, the level of offerings of the three value dimensions (functional, emotional and social) were analysed across different categories. Since user preferences may differ from product to product, comparisons were made for five categories of CIoT products (smart home devices, wearable devices, healthcare devices, connected vehicles and assistance devices). These results are shown in Figure 6.

Figure 5 Detail value offerings (see online version for colours)

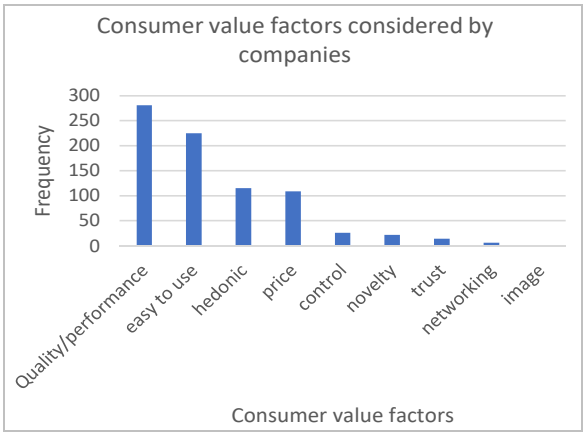


Figure 6 The three value dimensions across CIoT product categories

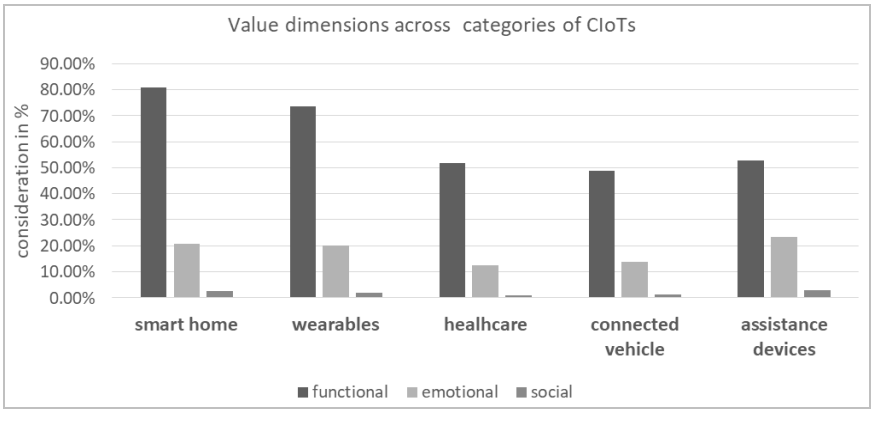
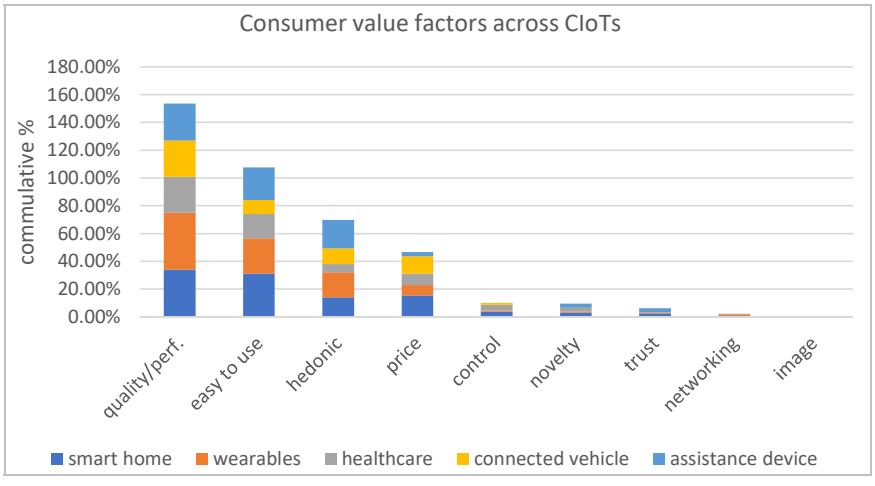


Figure 7 Value offerings across CIoT product categories (see online version for colours)



Looking at the three dimensions of value in detail, shows that four factors (quality/performance, easy-to-use, price and hedonic) are offered the most in the five categories (see Figure 5). Figure 7 shows the value offerings across the different CIoT product categories.

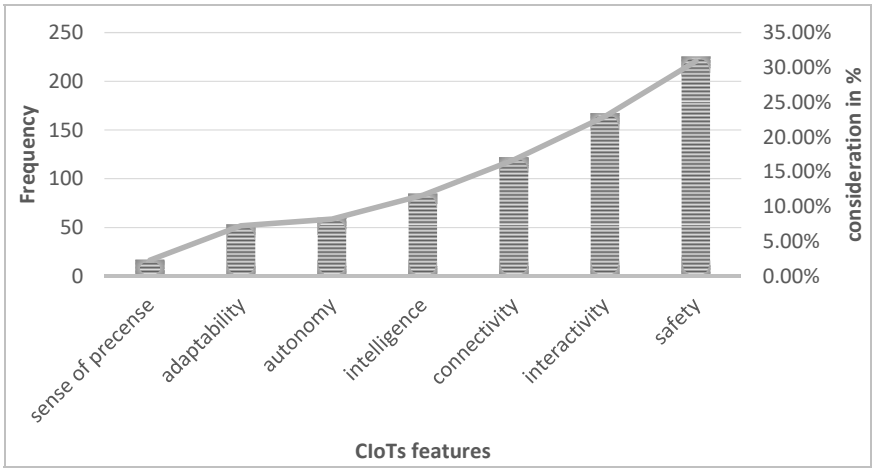
We also compared the two most important functional elements (quality/performance, easy-to-use) across different product categories. The comparison across the five CIoT product categories is better summarised using the matrix shown in Table 5. The result revealed that companies are proposing products with a greater emphasis on product value related to functions.

Table 5 Comparison of offered functions across CIoTs categories

CIoTs / *Factor*	*Smart home devices*	*Wearable devices*	*Healthcare devices*	*Connected vehicle*	*Assistance devices*
Quality/performance	XXX	XXX	XXX	XXX	XXX
Easy to use	XXX	XXX	XXX	XXX	XXX
Price	XX	X	X		
Hedonic	XX	XX	X	X	XX
Control	X		X		
Novelty	X				
Image/status					
Trust	X				
Networking		X			

Note: XXX – often considered, XX – sometimes considered and X – rarely considered.

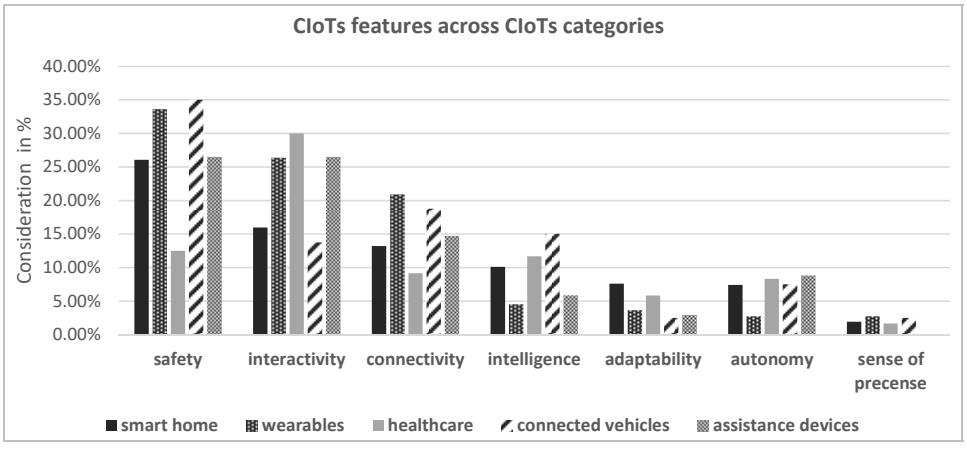
Figure 8 CIoTs features considered by companies



4.2 Consumer IoT product features

CIoT features are design goals that can enable better user experiences. From the available features covered in literature, the most often considered features based on the frequency of use were applied. Accordingly, the most common features considered by companies when developing these products are summarised in Figure 7. In Figure 8, the frequency describes how often each product feature was considered by companies in the design and development process, while percentages represent the ratio of the frequencies of the individual features to the cumulative occurrence of the features in the data.

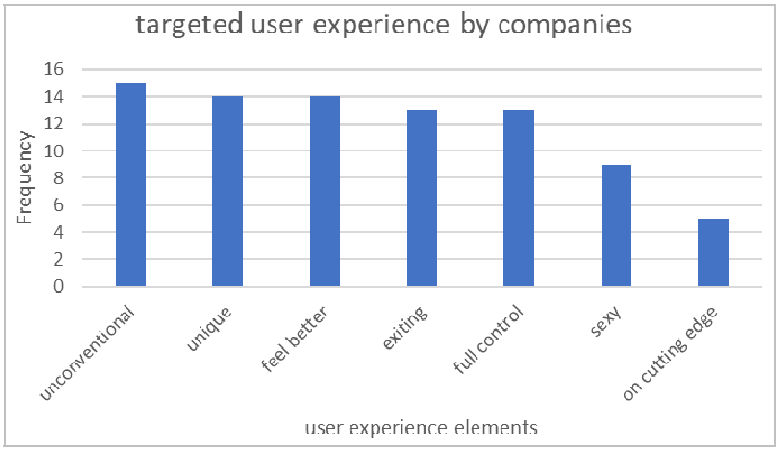
Figure 9 Comparison of CIoTs features across categories



Next, the seven CIoT product features were analysed to learn, how companies prioritise these features across different product categories. Safety, interactivity, and connectivity were the three most important features in almost every category. For healthcare devices, this was somewhat different, as the most important feature was interactivity, followed by

connectivity and safety. Figure 9 summarises the CIoT features across different categories.

Figure 10 User experience factors targeted by companies (see online version for colours)



4.3 User experience

Considering these factors at the elemental level, this paper identified the most targeted user experiences for CIoT products. Accordingly, companies are trying to develop products that can make users feel better when using them, feel exited in using, and provide unconventional and unique experiences for the user. The results are illustrated in Figure 10.

5 Discussion

5.1 Value propositions in the emerging businesses

The development of an IoT-based product/service value proposition is a challenging task since it may require the integration of multiple IoT architecture technologies, such as sensors, various types of networks, big data, analytics, and machine learning, among others to generate value (Molling and Zanela Klein, 2022). However, research in consumer IoT thus far needs better show mechanisms and ways to design better value proposition. In today's experience-driven consumption, considering a balanced mix of product value (functional, emotional, social), and CIoT features will improve user experience. Even though there are trending improvements in responding to consumer preferences and desires, companies have not been able to develop CIoT products that have been fully adopted by consumers. This research revealed that emerging companies are focusing on delivering product value related to functional aspects. It is obvious that consumers need such functions, but these are not the only desires recently voiced by users. Emotional aspects and social factors are also highly important product value aspects that should be considered to produce desirable and relevant products. Rokonuzzaman et al. (2022) pointed out that if companies want to see customers use their

products, they should focus on emotional value aspects than functional value. Due to the involvement of third parties (service providers), and the ability of these products to share real-time data, social value is also becoming an important dimension recently. The social value aspects of the CIoT products were not considered significantly to product design and development. The social aspects of product value are commonly overlooked in CIoT research (Shin, 2015), and these aspects are also not understood or incorporated into the design and development of these products by emerging businesses.

This research identified detailed and specific value propositions offered by emerging companies. Functionally, the most important product values provided by emerging CIoT companies to their users were better performance, energy efficiency, easy-to-operate/learn and understandability. Companies understood that users will adopt a technology if they believe that doing so will improve their performance in carrying out specific tasks (Ranjan et al., 2022). Emotionally, products with better aesthetics, and ability to relax in using are given better. However, social acceptance (image/status), networking, and trust are the most important social value elements emerging companies have failed to address in their current products. It is essential to note that, when purchasing consumer IoT devices, users need feel secure in using the device and seek to their friends for assistance (Jaspers and Pearson, 2022) to trust the device.

This research also made analysis to identify value proposition differences among different groups of CIoT products. In all five CIoT categories considered for the analysis, companies prioritised functional value than emotional and social values. The emotional aspects of products were relatively important in the development of smart home devices, wearable devices and healthcare devices. For the development of smart home devices, social aspects were included as a reliability factor. However, in general, companies did not prioritise social aspects in the creation of other CIoT products. In smart home devices, better performance, usefulness, and energy efficiency were most often considered functionalities that might make products desired by consumers. 'Energy efficiency' was only an important consideration for smart home devices. For wearable products, better performance and usefulness were the most important propositions. Easy-to-operate/learn, simplicity (easy to understand), and flexibility were important value propositions in almost every CIoT product categories.

Emerging companies in IoT also considered seven significant CIoT features when designing products. Failure to consider the right feature combinations can lead to undesirable products that do not capture the market. Safety (security and privacy), interactivity, and connectivity were the three features that were prioritised the most often by companies. Intelligence, adaptability, and autonomy were the second most considered features. In this context, intelligence is described as the degree of automated functions, the ability to perform complex configurations, and the ability to perform tasks without complex reasoning process (Pinochet et al., 2018). A few companies considered a sense of presence/observability to be an important design goal of CIoT products.

To further understand these features, a detailed analysis was performed for the three most important features in the sample: safety, interactivity and connectivity. Safety mainly incorporated the issues of security, privacy, and protection (personal, property). Personal protection refers to the ability to keep individuals from unpredicted injuries, failures, and accidents, while property protection refers to keeping property safe from robbery, damage, or accidents. In the literature, safety was mainly related to security and privacy issues. However, the analysis of the value propositions of companies revealed that protection is also an important safety element. In this regard, companies are

emphasising protection (personal, property) more than security and privacy. In fact, the issue of privacy was almost completely neglected by companies, even though consumers remain sceptical about using these products due to the issue of privacy. These companies should think about enhancing consumer IoT functionality and connectivity to offer more user-friendly configuration options for selecting their own privacy disclosure settings (Jaspers and Pearson, 2022). The second important feature considered in the development process was interactivity. The analysis showed that, interactivity is primarily related to easy information sharing, convenient communication, and real-time feedback. Companies predominantly focused on creating products that can easily transfer information with each other or with people, give timely feedback, and communicate conveniently. The third important feature was connectivity, which was understood as the ability to connect these products to the world via the internet. Companies interested in this feature sought to enable CIoT products to connect to the world through different media, to connect these products to each other, or to enable these devices to connect with people.

Almost all five categories of companies prioritised safety, interactivity, and connectivity in their value statements. For healthcare devices, interactivity was a more important feature than safety whereas security was prioritised for smart home devices and connected vehicles. The issue of privacy was not significantly considered in all the CIoT product categories.

5.2 Implications

The result of the study provides interesting implications for academicians and researchers. First, this study proposed a value-based framework that can be taken as a basis for future research examining value proposition in the actual value-creation process. Based on the theory of consumption value and product design principles, a value-based framework was developed. The proposed framework showed how to examine product value propositions in the actual value-creation process. By integrating product desired value, product features, and user experience, the research added a basic contribution to the existing body of knowledge to the consumer IoT study. Rather than simply considering value dimensions at a general level, the research also showed how each value dimensions should be examined at the elemental level. For the three desired value dimensions, nine elemental level value factors were considered. Such contributions can be built upon in further studies, benefiting researchers, policy development and R&D platforms.

The proposed framework will make sure the product to be desirable. Desirability in this context is holistic beyond just focusing on functional aspects. The proposed framework will make sure the product is usable to the intended user, the design is intuitive and easy to understand, the product is safe and reliable, the product is able to perform its intended function effectively, and will make sure the product has a meaning. The emotional and social aspects of desirability can give meaning to the product beyond functionalities. The framework also allows a user-centred approach to consider user desires in the product development and design stages.

The research identified product value dimensions and the respective specific elements that companies should consider in the design and development of CIoT products. This study has also identified the CIoT features that producers should consider the most when seeking to provide a better user experience. From a more practical point of view, this

paper identified design considerations, and user-desired features by looking at the actual products produced by the emerging companies. The result of the study will help designers, manufacturers, and marketers to understand and prioritise design considerations so that they can respond to future user needs and preferences. Companies can use the proposed value-base framework in developing desirable products. It will give important basics for company managers where to focus in developing CIoT products and put themselves in a better market position.

6 Conclusions

Consumer IoT sector is one of the newly emerging business sectors due to the emergence of IoT technology. Businesses are emerging in this sector producing end-application devices. These emerging businesses face a challenge of producing products with better user-experience that could be desirable to the user. This paper examined value propositions of emerging businesses in consumer IoT. Accordingly, value factors that are given better attention as well as value factors emerging businesses failed to address were identified. For this purpose, a value-based framework which can be used to design consumer desire-based products was developed. Product desired value, product features, and user experience were integrated in this framework to analyse value proposition following the actual value creation process.

This paper has some limitations that can be overcome by future research. First, the scope is limited to emerging businesses in the consumer IoT sector. The research considered emerging companies that are in their early stages, characterised by extreme uncertainty and high growth potential, that are lacking stable business models. However, there are also companies big-in-size, leading in the sector, and with stable business models. Future research could be conducted by expanding the scope to the leading companies in consumer IoT sector, and comparing the value proposition results with emerging businesses might give different outcomes. Second, this research explored product value propositions from the companies' perspective. The value-based framework proposed in this paper mainly focused on identifying desirability factors in improving the user experience. However, we explored these desirability factors based on the data extracted from companies' descriptions in the CrunchBase platform. Future research can use the proposed value-based framework to examine consumer value of products of these companies from the user perspective. A comprehensive map of desirability of CIoT products could be developed analysing the results of the two perspectives: company perspective and user perspective. Third, the CIoT product classifications developed in comparing value propositions across different product categories are based on the products produced by emerging businesses. If products produced by leading companies in the sector are considered, a different classification of CIoT products might be obtained. Developing a comprehensive classification of CIoT products based on sound classification criteria can be an import future research direction. Overall, the research in the consumer IoT is still at its early stage that needs future research in every aspect. We hope that the proposed value-based framework, and the results presented in this paper will help future research in understanding the value propositions and product desirability in consumer IoT context.

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Notes

1 https://www.angellist.com/about.

2 https://mattermark.com/.

3 https://tracxn.com/.

4 Company name was changed to keep company privacy.