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A STUDY ON REVENUE MEASUREMENT AND PERFORMANCE EVALUATION IN AN IOT ECOSYSTEM IN CHINA: FROM PLATFORM OWNER'S PERSPECTIVE

TABLE OF CONTENTS

Executive Summary 5
Chapter 1 Introduction of IoT and IoT Products 6
1. The Development of IoT in China 6
2. Characteristics of IoT Products 9
Chapter 2 IoT Ecosystem: The Three-layer Business Model 10
1. Application layer 10
2. Platform layer 11
3. Infrastructure layer 12
4. Competitive advantages 12
Chapter 3 Measuring Revenues 14
1. Comparison of Revenue Models between IoT Ecosystems and Traditional Businesses 14
2. Revenues from One-time Direct Users 14
3. Revenues from Recurring Direct Users 14
4. Revenues from Cross-over Users 15
Chapter 4 Evaluating Performance 16
1. Comparison of Performance Evaluation between IoT Ecosystems and Traditional Businesses 16
2. Objectives, Performance Drivers, and Metrics 18
Conclusion 21
Initiative 1: Enhance User Acquisition, Retention, and Engagement 21
Initiative 2: Improve Entry Criteria, Support Systems, and Exit Mechanism for Partners 21
Initiative 3: Create and Enhance Synergies 21

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EXECUTIVE **SUMMARY**

In today's digitalized world, the advent of Internet of Things (IoT) technology is transforming our lifestyle and work methods. IoT technology amplifies the user feedback loop, thereby encouraging users to purchase more products that complement their existing smart devices. This, in turn, enhances user loyalty to the platform and ecosystem. However, this innovative business model also poses challenges to platform owners in precisely measuring revenue streams and evaluating performance within an IoT ecosystem. Traditional business valuation tools view a company as an isolated entity, neglecting the value generated by business partners and users of different groups, such as one-time users and recurring users. Consequently, the application of traditional business valuation tools might produce distorted results. This study intends to offer a holistic framework for gauging revenues originating from different user categories and pinpointing business performance drivers within an IoT ecosystem's infrastructure, platform, and application layers. Furthermore, we also discuss metrics for assessing user engagement, platform infrastructure, and participant engagement.

The report uses case studies of IoT companies such as Haier, Xiaomi, Tuya, and others to exemplify business objectives, organizational structure, revenue measurement, and performance evaluation in their IoT ecosystems. These examples could act as beneficial tools for companies within the IoT ecosystem, aiding in the identification of potential opportunities for enhancing user growth, diversifying product offerings, creating network synergies, boosting revenue, and improving overall company value. For companies looking to establish or become part of an IoT ecosystem, this report provides insights on organizational design, internal controls, revenue measurement, and performance evaluation that are essential for success within an IoT ecosystem.

Our target audience primarily comprises:

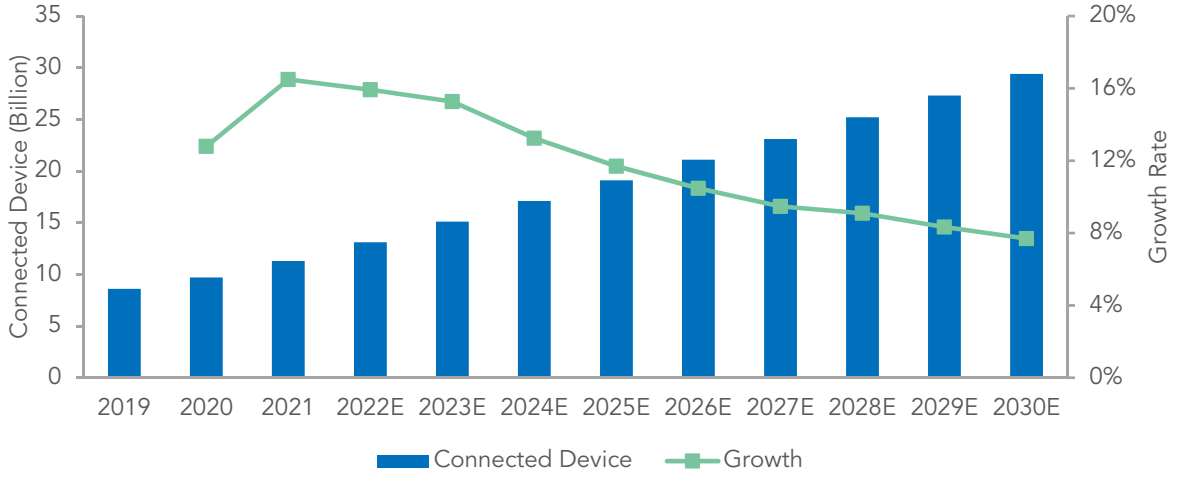
1. Management accountants who are interested in the business models and management control systems within an IoT ecosystem.
2. Business professionals who are employed in platform-based firms that bridge end-users and suppliers, including giants such as Amazon, Google, and Alibaba.
3. Students with aspirations to explore prospective careers in auditing, accounting information systems, cost management, budgeting and controlling, financial planning, and accounting data analysis within an IoT company.
4. Regulators striving to comprehend online user growth data, online traffic data, and the background operation data of certain platform companies, as well as those working on updating the securitization and tax policies related to these companies. •

Chapter 1
Introduction of IoT and IoT Products

1. The Development of IoT in China

As per the International Telecommunication Union (ITU), IoT is "a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies".[1] Since the formal introduction of this concept by the ITU in 2005, IoT has witnessed substantial progress over the last decade. Figure 1 depicts the annual worldwide trend of IoT-connected devices. The number of these devices is projected to nearly triple from 9.7 billion in 2020 to over 29 billion in 2030. These IoT-connected devices permeate all industrial and consumer markets, with the consumer sector accounting for approximately 60% in 2020, a percentage forecasted to remain consistent over the forthcoming decade. Within the consumer market itself, the primary application of IoT devices lies in end-user-centric devices such as smartphones. These end-user-centric IoT devices are expected to surge to more than 17 billion by 2030, with 5 billion devices operating in China, the world's largest consumer market for IoT devices.

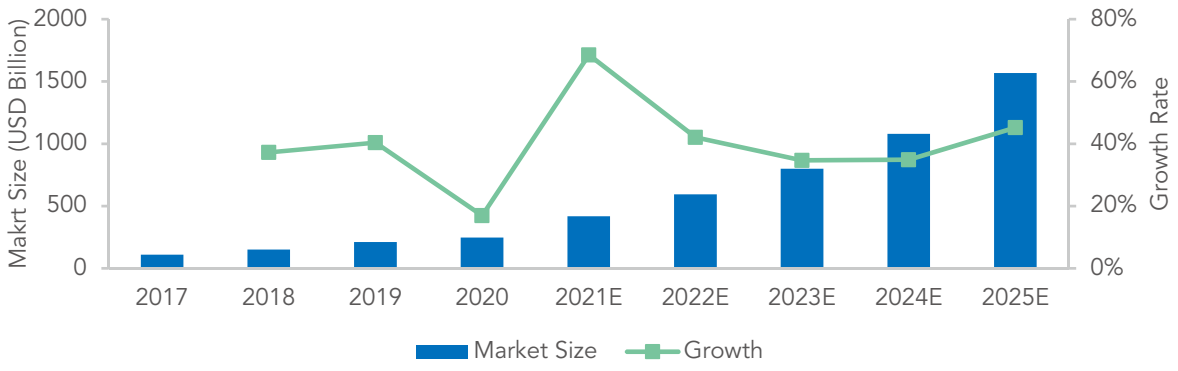
FIGURE 1: NUMBER OF INTERNET OF THINGS CONNECTED DEVICES AROUND THE WORLD



Source: Statista

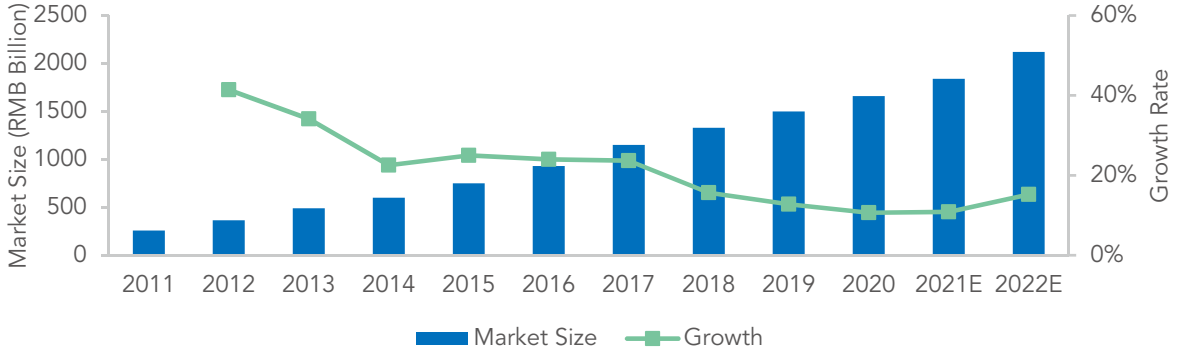
[1] *ITU-T Y.4000/Y.2060 (06/2012), https://handle.itu.int/11.1002/1000/11559*

FIGURE 2: GLOBAL MARKET OF INTERNET OF THINGS



Source: Statista

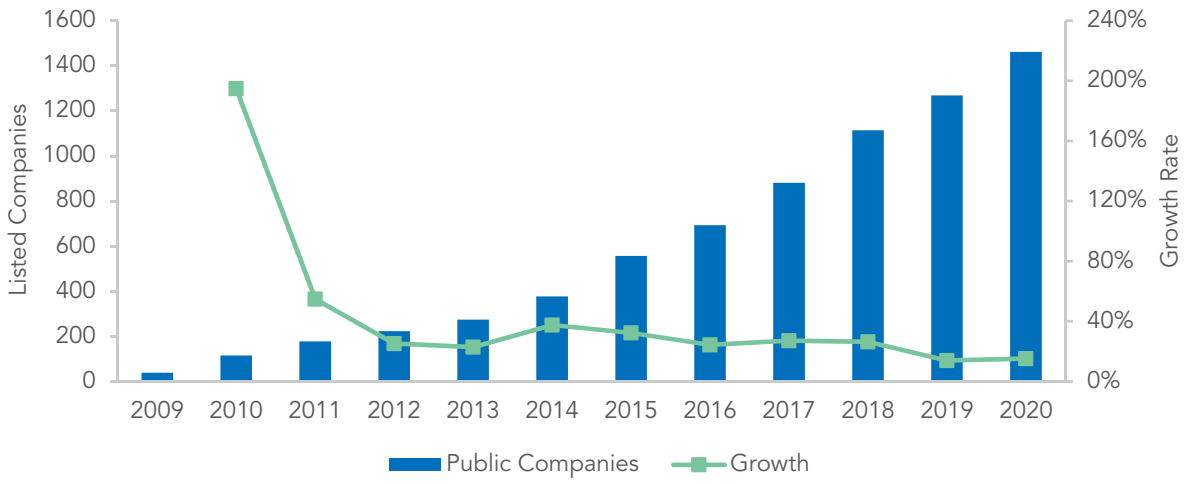
FIGURE 3: CHINA MARKET OF INTERNET OF THINGS



Source: China Industrial Development Institute (CIDI)

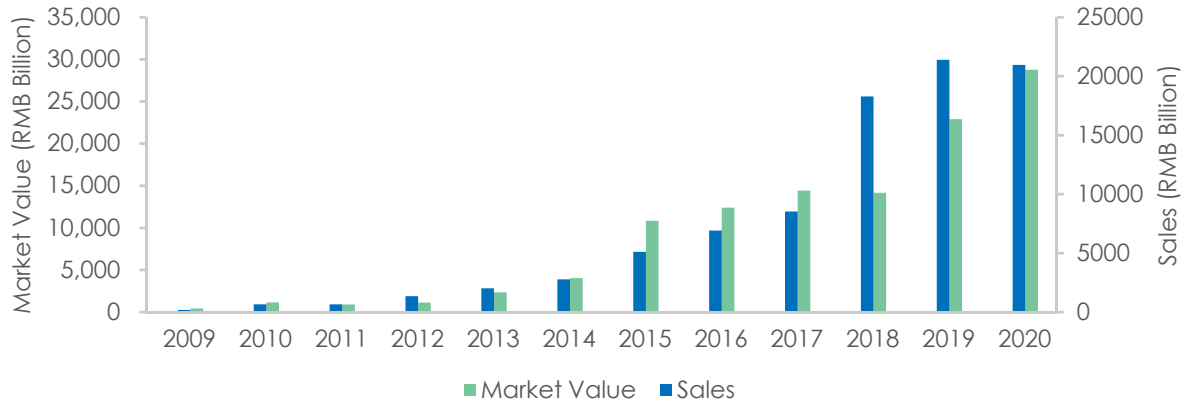
The market for IoT is experiencing growth on a global scale as well as in China. Figure 2 presents the size and the growth rate of the worldwide IoT market. The global market was valued at USD 248 billion in 2020 and is anticipated to expand at a compound annual growth rate (CAGR) of 40% from 2020 to 2025. Figure 3 details the size and growth rate of China's IoT market. China's IoT market stood at RMB 258 billion in 2011 and is projected to reach RMB 2,120 billion in 2022, marking a CAGR of 20%. This remarkable growth rate is primarily fueled by a significant rise in the number of smartphone users in China.

FIGURE 4: NUMBER OF INTERNET OF THINGS-RELATED PUBLIC COMPANIES[2] IN CHINA



Source: WinGo

FIGURE 5: MARKET VALUE AND SALES OF INTERNET OF THINGS-RELATED PUBLIC COMPANIES IN CHINA



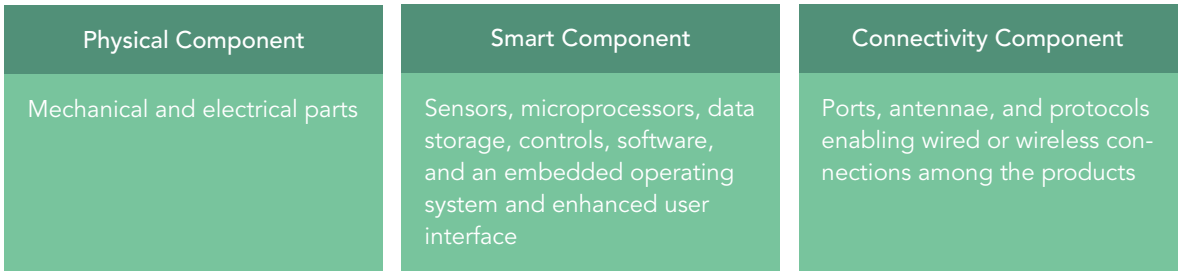
Source: WinGo, CSMAR

[2] We use the textual analysis method to identify IoT-related listed companies according to their financial statements. If a company mentions IoT-related terms in the financial statements, it means the company has IoT business now or has plans to expand into the IoT market in the future.

Figures 4 and 5 depict the quantity of IoT-related public companies, along with their cumulative market values and sale revenue over time. In 2009, the Internet of Things was a relatively nascent concept for Chinese firms, with a mere 39 IoT-associated listed companies in the market. However, by 2020, as many as 1,462 publicly-listed companies had IoT-related operations or planned to venture into the IoT market, comprising approximately 35% of China's total number of publicly-listed firms. As the count of public companies escalates, their cumulative market value and sale revenue witness rapid growth as well. For instance, the combined market value of the IoT-related listed companies had surged markedly from RMB 427 billion in 2009 to 28,800 billion in 2020, yielding a CAGR of 47%. Concurrently, the aggregate sales revenue leaped from RMB 189 billion in 2009 to RMB 20,960 billion in 2020, marking a CAGR of 53%.

2. Characteristics of IoT Products

FIGURE 6: THE STRUCTURE OF IOT PRODUCTS



Source: Porter and Heppelmann, 2014

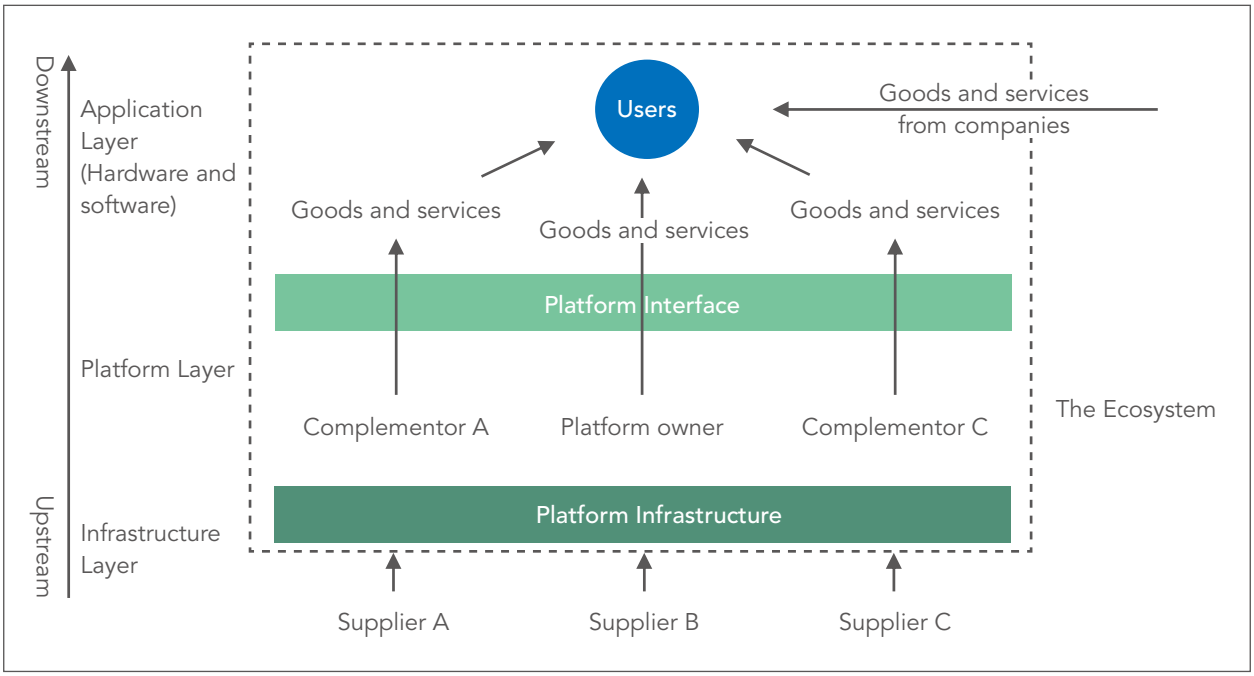
According to Porter and Heppelmann, IoT products comprise three elements: the physical component, the smart component, and the connectivity component (see Figure 6).[3] Given the increased capacities and accrued data of "things", Porter and Heppelmann postulate that IoT represents the third wave of IT-driven transformation of competition. This wave introduces new functionalities at the product level, including monitoring, control, optimization, and autonomous operation, thereby presenting tremendous potential for product differentiation. At the corporate level, IoT enables more informed and value-enhancing activities, including marketing, R&D, procurement, and after-sales services, compared to traditional businesses. Companies across different industry segments might cooperate to restructure their value chain. For instance, domestic appliance manufacturers could collaborate with a tech company offering security solutions. As a result, "the basis of competition thus shifts from the functionality of a discrete product to the performance of the broader product system, in which the company is just one actor. "[4]

[3] Porter, M.E. and Heppelmann, J.E. (2014) 'How Smart, Connected Products Are Transforming Competition'. Harvard Business Review, November.
Porter, M.E. and Heppelmann, J.E. (2015) 'How Smart, Connected Products Are Transforming Companies'. Harvard Business Review, October.

[4] Porter, M.E. and Heppelmann, J.E. (2014) 'How Smart, Connected Products Are Transforming Competition'. Harvard Business Review, November.

Chapter 2
IoT Ecosystem: The Three-layer Business Model

FIGURE 7: ANALYTICAL FRAMEWORK OF THE BUSINESS MODEL OF IOT ECOSYSTEMS



An IoT ecosystem is referred to as a network of autonomous entities collectively offering complementary goods and services to customers, with IoT technology as a foundational component. Figure 7 illustrates an analytical framework for the business model of an IoT ecosystem. The IoT architecture is segmented into three layers from a traditional supply chain perspective: infrastructure, platform, and application. Each layer is discussed in detail below.

1. Application layer

The application layer forms the topmost layer of an IoT ecosystem, encompassing IoT hardware devices and software applications that directly interact with users.[5] This layer comprises smart devices and integrated end-user software, equipping users to effortlessly deploy, connect, and manage their smart devices. It pertains to various scenarios in which IoT devices can be deployed, such as smart homes, smart cities, and smart health. For instance, within the smart health scenario, numerous health and fitness applications monitor an individual's physical health, diet, exercise, and lifestyle, subsequently

[5] We use the term "user" to emphasis that IoT ecosystems tends to build long-time relationships with its clients, instead of "consumer", which is more transaction-based.

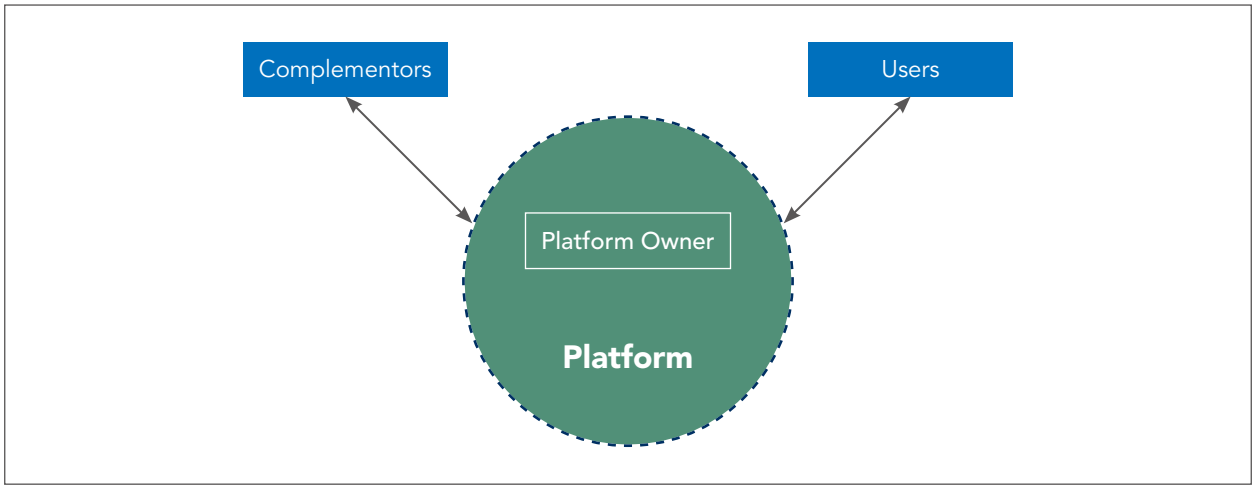
providing tailored health recommendations. As a result, users may grow more reliant on the services provided by the application layer, generating recurring revenue. Such applications construct a user-orientated ecosystem of products and services to secure user loyalty.

2. Platform layer

The middle layer is referred to as the platform layer or the platform interface. For instance, video game consoles such as Microsoft's Xbox and Sony's PlayStation serve as platforms, facilitating the development of complementary games by third-party developers and their usage by end-users. As illustrated by the video game console example, a platform layer typically incorporates at least three types of participants, as depicted in Figure 8:

1. Platform owner, who owns or sponsors the platform and sets standards for third-party companies. Generally, this is a leading industry company equipped with the necessary resources and talents to guide the future development of the platform, akin to Microsoft for Xbox and Sony for PlayStation.
2. Providers of complements, also known as complementors, are third-party companies that align or delegate their production and customer engagement activities to the platform while preserving a degree of autonomy, such as the third-party game developers. Complementors enhance the platform's value by providing personalized goods and services to end customers.[6]
3. Users, who are ultimate consumers of the products and services delivered by both the platform owner and the complementors.

FIGURE 8: THE PLAYERS ON A PLATFORM



For example, Tuya, a Chinese AI and IoT company, has established an IoT cloud platform. On the one side, the platform delivers a user interface, enabling end-users to conveniently search for and manage multiple devices from various vendors. On the other side, it equips independent brands with diverse business capacities, ranging from infrastructure support, security, and monitoring to data analytics and end-user management. The freedom allows management to streamline operations, thereby enhancing operational efficiency and reducing costs. The two-way integration platform has helped Tuya acquire a large customer base.

[5] Jacobides, M.G., Cennamo, C. and Gawer, A. (2018) 'Towards a theory of ecosystems', Strategic Management Journal, 39(8), pp. 2255–2276. doi:10.1002/smj.2904.

3. Infrastructure layer

The foundation layer is known as the infrastructure layer or the platform infrastructure. This layer provides standards, toolkits, or workspaces for businesses to streamline production activities and manage the supply chain. The infrastructure layer can be likened to a data center endowed with storage, computing, and network capabilities. Companies can construct their own IoT systems using toolkits and cloud-based services supplied by infrastructure layer providers. By saving the time and resources that would be spent on establishing infrastructure and equipment from the group up, IoT ecosystems enable businesses to concentrate on supply chain management, production innovation, and the enhancement of customer relationships.

Consider the example of a Chinese retail apparel company, Peacebird Fashion (hereinafter referred to as "Peacebird"). Peacebird was grappling with various sales bottlenecks, including an inventory backlog, substandard product design, and inefficient store management. To resolve these issues, Peacebird embarked on several digital transformation projects, which included updating the IoT-based infrastructure hardware and deploying a new software system. Some of these projects encompassed the implementation of retail store inventory management devices and online networks to consolidate real-time sales data and user feedback. All operations, extending beyond inventory and customer relationship management, are configured using the system for automatic and timely decision-making. As a result, Peacebird attained zero inventory and realigned product lines at minimum costs by relying on this system.

4. Competitive advantages

The cornerstone of the competitiveness of an IoT ecosystem as a business model lies in its ability to construct a micro-market with "visible hands". This is the initiatives and coordination led by the platform owner that outperforms the macro-market operating with invisible hands. The superiority is attributable to the network effects, a shortened user feedback loop, and the efficiency in resource allocation.[7]

Primarily, network effects refer to scenarios where the network's value escalates with the increase in participant count. For instance, the value of the IoT ecosystem of Haier, one of China's leading IoT companies, grows with the rise in the number of users and third-party providers. Furthermore, the IoT ecosystem functions as a two-sided, platform-led market involving both businesses and individuals, hence, experiencing both direct and indirect network effects.

Direct network effects are contingent on the number of participants capable of interacting within the ecosystem. As the community of enterprises and individuals enlarges, user loyalty augments while the marginal cost for businesses (for instance, promotional and transaction costs) diminish. This development, in turn, amplifies the network effects. To illustrate, consider Haier's smart living room. If users already possess Haier TVs and are satisfied with the company's products and services, they are more prone to purchase Haier projectors to synchronize with their TVs and other smart living room devices.

On the other hand, indirect network effects arise from the variety offered by third-party complementors. Following Haier's smart living room example, when a considerable user base benefits from its smart living room devices, its ecological partners, such as companies that manufacture IoT products for bedrooms, study rooms, and kitchens, will find joining Haier's ecosystem more profitable due to its extensive customer base.

[7] Jacobides, M.G., Cennamo, C. and Gawer, A. (2018) 'Towards a theory of ecosystems', Strategic Management Journal, 39(8), pp. 2255–2276. doi:10.1002/smj.2904.

Moore, J.F. (2006) 'Business Ecosystems and the View from the Company', The Antitrust Bulletin, 51(1), pp. 31–75. doi:10.1177/0003603X0605100103.

Secondly, shortened user feedback loop ensures effective and efficient routing of user feedback to corresponding complementors. As an illustration, consider a user purchasing an electric vehicle. The embedded IoT device within the vehicle can monitor performance, alert the user to recharge the battery or change the tire as required, and suggest relevant vehicle supplies. The expedited feedback loop not only generates value for the users but also enhances the agility and competitiveness of the complementors.

Lastly, the platform owner, the principal sponsor of the ecosystem, can impart or delegate some of its efficient internal practices, such as application development techniques or quality control standards, to the ecosystem and hence, to the complements providers. Consequently, the complementors can employ these tools for their development instead of initiating from scratch, which boosts the ecosystem's overall resource allocation efficiency. The collaborative exchange of resources and insights among the participants fosters mutual benefits surpassing the revenues they could attain individually. •

Chapter 3
Measuring Revenues

1. Comparison of Revenue Models between IoT Ecosystems and Traditional Businesses

In essence, companies record and document their transactions based on an assumption of separate-and-independent accounting entities. However, such methods do not satisfy the managerial requirements of platform owners to measure revenue streams in an IoT ecosystem, where diverse entities collaboratively deliver goods and services.

The revenue measurement methods in IoT ecosystems significantly deviate from traditional approaches. It initially categorizes revenue according to user type rather than good or service type. The driving factor behind intercompany collaboration is user needs, from which the ultimate value of the ecosystem derives. Simultaneously, users are indispensable assets within the IoT ecosystem. Some of these users can promptly provide feedback tailored to highly personalized, customized, and contextual needs, thereby enabling companies to adjust their value-creation activities swiftly. This rapid adjustment represents a new form of value co-creation in the IoT ecosystem.

Users, depending on their transaction frequency and level of integration into the IoT ecosystem, can be grouped into three categories: one-time direct users, recurring direct users, and cross-over users. Each group's impact on the ecosystem varies. The measurement and understanding of revenues generated by these user types offer two key advantages. Firstly, it allows for an accurate assessment of the ecosystem's overall value and facilitates the distribution of benefits among various parties. Secondly, it aids in continuous monitoring, evaluation, and enhancement of the ecosystem's value-creation process.

2. Revenues from One-time Direct Users

The initial source of revenue is derived from one-time direct users. One-time direct users are largely attracted via marketing activities and typically procure physical products, with IoT technology offered as an ancillary service bundled together. Consequently, their engagement in the ecosystem's evolutionary process is minimal, and the revenue they generate does not echo the network effects and the ecosystem's synergy. Nevertheless, their transactions can act as a foundation for future dealings should they find satisfaction in the product provided and decide to purchase additional goods or services within the ecosystem at a later time.

3. Revenues from Recurring Direct Users

The second type of revenue is accrued from recurring direct users who engage in numerous transactions within the IoT ecosystem. Typically, these users procure only complementary physical goods, and IoT technology can augment their experience by enhancing the ease of purchasing related products. For instance, Bluetooth earphones can serve as complementary physical products (related products) associated with a mobile phone purchase. When a user procures a mobile phone from Xiaomi, a Chinese mobile phone and smart hardware company, and requires Bluetooth earphones, they are more likely to opt for Xiaomi earphones. This is due to stronger compatibility among products within the same IoT

ecosystem, including factors such as connection stability and sound quality. This enhanced compatibility from the same IoT ecosystem contributes to the convenience and quality of users' purchase and consumption experiences. As the initial physical product, mobile phones heighten users' preference for other complementary products, stimulating multiple transaction behaviors within the IoT ecosystem.

Compared to the initial source of revenue, income derived from recurring direct users boasts greater user stickiness and increased user switching costs. These users exhibit a lower likelihood of transitioning to comparable products offered outside of the ecosystem, thereby establishing a competitive advantage for the ecosystem. In this scenario, IoT technology enables resource sharing among ecosystem members but necessitates high complementarity among the products offered.

However, transactions carried out by recurring direct users may be restricted and incapable of sustaining the ecosystem's self-renewal over time. In other words, they do not contribute to the ecosystem's continuous improvement in product quality or the maintenance of a competitive edge. In the aforementioned example, for recurring direct users, IoT technology merely represents an ancillary service offered alongside mobile phones and Bluetooth earphones, rather than a primary product for which users are willing to pay.

4. Revenues from Cross-over Users

The third revenue stream in an IoT ecosystem is derived from cross-over users. The term "cross-over" is employed to underscore the synergistic values crafted by a broad assortment of complementary IoT products for users. Unlike the second type of revenue, revenue stemming from cross-over users is primarily propelled by IoT technology. For these individuals, their lifecycle consumption is intimately linked with this IoT ecosystem, as purchasing products outside the ecosystem imposes significantly high switching costs. Such users demonstrate robust user loyalty and constitute the most invaluable assets of the ecosystem.

Consider the journey of an individual user as an example. Initially, this user procures a home appliance from Haier, subsequently discovering the capability to remotely control the device via the "Haier Smart Home" mobile phone App. This convenience entices the user to acquire a variety of home devices, thereby transitioning into a cross-over user. Picture this scenario – en route home, the user employs the App to remotely activate the air conditioner, rice cooker, and cleaning robot. Upon arrival, the user is greeted by an optimally comfortable room temperature, freshly prepared rice, and a pristine floor. Moreover, any dissatisfaction with the products can be communicated directly to Haier through instantaneous feedback within the App, aiding Haier in refining its product line. On the whole, Haier's IoT ecosystem caters to users' convenience by effectively addressing their needs in various home-related situations. By deeply embedding into the user's living environment, Haier's products offer unrivaled ease and control by capitalizing on IoT technology.

Cross-over users play a crucial role in augmenting the ecosystem's value. On the one hand, they furnish the ecosystem with direct feedback from the consumer market, facilitating product enhancements and ecosystem self-renewal. On the other hand, they can actively engage in the ecosystem's evolution by proposing new consumption scenarios and broadening the ecosystem's matrix horizontally. •

Chapter 4
Evaluating Performance

1. Comparison of Performance Evaluation between IoT Ecosystems and Traditional Businesses

Traditionally, an organization's performance was evaluated from financial aspects, utilizing metrics such as Return on Equity (ROE) or Return on Assets (ROA). This retrospective approach, based on lag financial data, was insufficient for informing long-term business prospects. The Balanced Scorecard (BSC), introduced by Kaplan and Norton in 1992, has supplemented this area by integrating financial and non-financial components into four interconnected perspectives: Innovation and Learning, Internal Business, Customer, and Financial.[8] For instance, training can enhance human capital, subsequently improving internal processes. This improvement leads to more efficient product delivery, culminating in increased customer satisfaction and financial returns. When the BSC is used in conjunction with the strategy map, companies can break down their strategies into business objectives and then identify metrics associated with these objectives to measure progress in strategy implementation. Unlike traditional financial methods, the BSC suggests a forward-looking approach to performance evaluation by including non-financial perspectives like employee skills and client relationships. The underlining assumption of BSC is that companies that transitioned from the industrial era are more adept at measuring tangible assets, such as machinery and equipment, rather than intangible ones, like knowledge and innovation. These intangible assets have become increasingly critical in dealing with competition and the rise of information technology.

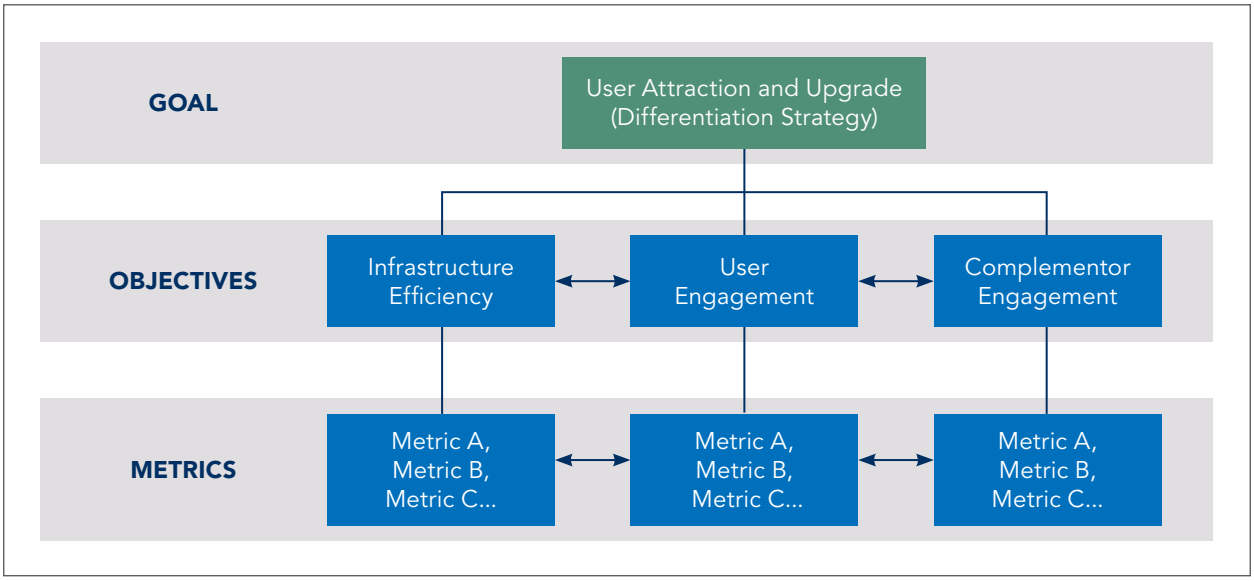
However, performance evaluation must continue to evolve in the IoT era to accommodate the new business context due to three challenges. The first is the aforementioned increase of users in business relationships, making user-oriented measures a vital dimension of performance evaluation. Users are not only sources but also catalysts for the network effects of ecosystems. Solely utilizing the size of the user base or the degree of customer satisfaction as measures does not adequately capture their dynamics. Companies need to comprehend users and their upgrade paths from contexts in which they consume IoT products. Secondly, overlapping company boundaries complicate the definition of objectives and the setting of metrics. The interactions among companies from the same or different IoT layers are so intense and close that some core internal functions are delegated to others, rendering their relationship fundamentally different from outsourcing. The third challenge lies in the measurement of the performance of ecosystem infrastructure. The infrastructure includes both base-level standards targeting complementors that define IoT devices and cooperation agreements, and top-level standards targeting users that aim to offer a consistent user experience.

Hence, we propose an integrated performance evaluation framework for IoT ecosystems from the perspective of the platform owner, which plays a pivotal role in the IoT ecosystem, as depicted in Figure 9. This framework, adapted from BSC and the strategy map, is divided into goals, objectives, and metrics.[9] The goal should reflect the company's strategic differentiation aim in the ecosystem, ultimately designed to attract and upgrade ecosystem users. For instance, a nascent brand would adopt a strategy distinct from that of Amazon. The objectives include three fundamental dimensions for evaluating an

[8] Kaplan, R.S. and Norton, D.P. (1992) 'The Balanced Scorecard—Measures that Drive Performance', Harvard Business Review, January.
[9] Kaplan, R.S. and Norton, D.P. (1992) 'The Balanced Scorecard—Measures that Drive Performance', Harvard Business Review, January.

IoT ecosystem: user engagement at the core, complemented by complementor engagement and infrastructure efficiency. Metrics are specific indicators that should reflect progress towards objectives reliably and measurably, defined in limited quantities to maintain focus. Causal relationships from metrics to objectives, and from objectives to the goal, should be established.

FIGURE 9: FRAMEWORK OF PERFORMANCE EVALUATION OF AN IOT ECOSYSTEM



A practical illustration of this framework is Haier's Win-Win Value Added Statement (WWVA), as depicted in Figure 10.[10] This user-centric performance evaluation approach, explicitly crafted for ecosystems established by or stemming from Haier, classifies partners (i.e., complementors) into interaction partners and active partners, and categorizes users into transaction users, interaction users, and lifetime users, based on their contribution to the ecosystem. It's noteworthy that these three types of users correspond to one-time direct users, recurring direction users, and cross-over users, respectively.[11] The WWVA enhances traditional financial statements with a comprehensive approach that encompasses users, partners, traditional and ecosystem-level costs and revenues across six sections: User Resource, Partner Resource, Ecosystem Value, Revenue, Cost, and Marginal Revenue. The final section, Marginal Revenue, equals the margin (i.e., Revenue minus Cost) per transaction user.

The structure of the WWVA aligns with the proposed framework by mapping the User Resource section to the user engagement objective, the Partner Resource section to the complementor engagement objective, and the Cost section to the infrastructure efficiency objective. Fundamentally, the WWVA indicates the degree of the ecosystem's efficiency and effectiveness by assessing the dynamic process in which the Marginal Revenue escalates due to network effects. This process presumes that the advancement of users to the subsequent type, a phenomenon known as user multiples, will foster the

Frigo, M.L. (2012) 'The Balanced Scorecard—20 Years and Counting', Strategic Finance, October.

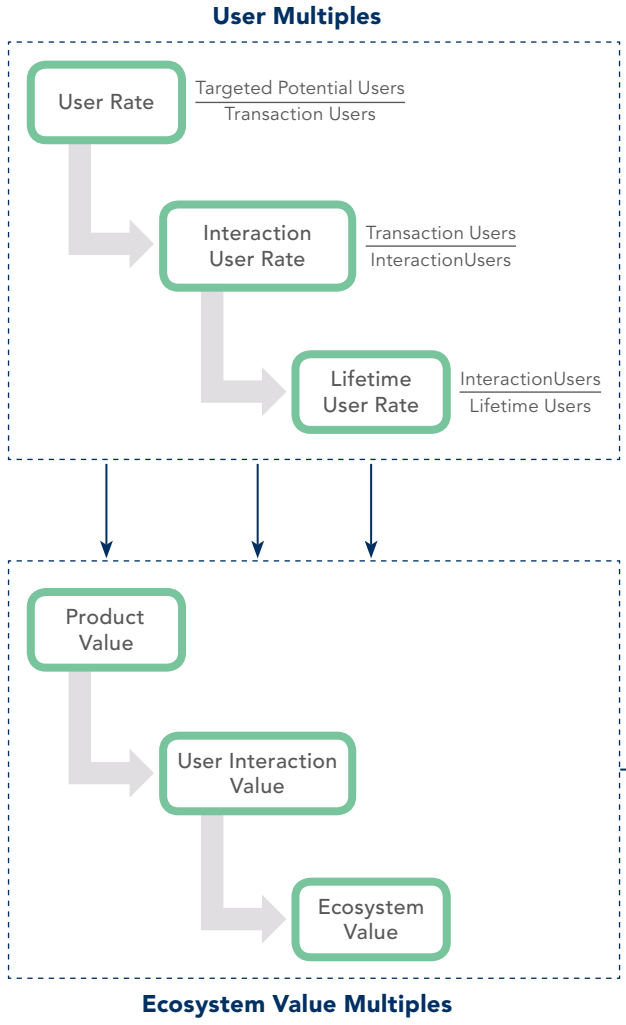
[10] Zhang, R.M., Jiang, Q.P., and Hu, G.D. (2018) 'Research on User Multiples and Value Management Based on Haier's 'RenDanHeYi' Model' (in Chinese). Chinese Journal of Management. 15(09):1265-1274.

IMA. (2020) 'The Win-Win Value Added Statement: Financial Tool in the Internet of Things Era' (in Chinese).

[11] The evaluation criterion of Haier's three user categories may vary across business lines or departments. In some cases, users are divided in more detailed categories to reflect the upgrading process, i.e., users upgrade from a lower level of category to a higher one, contributing more revenues to the ecosystem. Haier has developed an information system and made organizational adjustments to implement its ecosystem strategy. But these are out of the scope of this SMA.

value enrichment of the ecosystem, a concept referred to as ecosystem multiples. This happens as the marginal cost to serve diminishes and the marginal revenue expands along with the growth of the user base. Additionally, the WWVA furnishes a robust basis for variance analysis, encompassing comparison with historical and budgeted records, which can be harnessed to evaluate and enhance performance.

FIGURE 10: USER MULTIPLES, ECOSYSTEM VALUE MULTIPLES, AND THEIR REFLECTION ON THE WWVA



WWVA

1. User Resource	
Transaction Users	↑
Interaction Users	↑
Contribution per User	↑
Lifetime Users	↑
2. Partner Resource	
Interaction Partners	↑
Active Partners	↑
3. Ecosystem Value	
3.1 Profits	
Traditional Profits	→
Ecosystem Profits	1x→Nx
3.2 Value added Sharing	↑
4. Revenue	
Traditional Revenue	→
Ecosystem Revenue	1→N
Revenues per User	1→N
5. Cost	
Traditional Cost	→
Ecosystem Cost	→
Marginal Cost	→0
6. Marginal Revenue	
Marginal Revenue	1→N

Source: Zhang, R.M., Jiang, Q.P., and Hu, G.D. (2018); IMA (2020)

2. Objectives, Performance Drivers, and Metrics

Performance drivers represent a multitude of factors influencing performance, akin to how net income affects ROE. However, within the performance evaluation framework, performance drivers embody a concept broader than just revenue drivers, encompassing both financial and non-financial aspects, which incorporate both quantitative and qualitative measures. Well-structured metrics present numerous advantages. They can bridge the disparity between performance and its drivers, establish a shared

platform for communication, coordination, and operation among all ecosystem participants, and provide incentives to these participants. These elements collectively contribute to the establishment of a robust and comprehensive performance evaluation system.

Metrics for the user engagement objective can be formulated based on user behaviors, such as user acquisition cost and the conversion rate of users advancing to the next level. For example, ThundeRobot, a Chinese company that specializes in the design and sale of gaming computers and accessories, gauges user engagement through metrics like downloads, daily active users (DAU), monthly active users (MAU) of their own App, and the scale and activity of user groups across various channels, including China's WhatsApp-like WeChat.

More sophisticated metrics, including the Net Promotor Score (NPS) and Customer Performance Indicators (CPIs), can also be utilized. The former captures the likelihood of a customer recommending the ecosystem's products and services, while the latter consists of a curated collection of indicators that concentrate on aspects truly significant to customers rather than companies, such as efficient payment channels and complaint resolution rates. For instance, Tuya uses a dollar-based Net Expansion Rate to assess revenue increases generated by the same customer group across accounting and operation periods. In terms of bridging the physical and digital worlds, metrics can be formulated based on scenarios. These scenarios outline the ways in which users need, use, consume, or leverage IoT or IoT-based products. They can be categorized by location or activity, such as kitchen or fitness scenarios. These scenarios can be intensified and multiplied for product development and coverage purposes. The advantage of scenario-based metrics is that they enable companies to understand and meet users' needs more effectively by examining and expanding scenarios.

Metrics for the complementor engagement objective comprise two interconnected elements: supply chain management and business cooperation. Unlike a traditional company, a platform owner's distinction in supply chain management lies in the emphasis on value co-creation, rather than pursuing the lowest-cost supply in an upstream-downstream relationship. For instance, ThundeRobot periodically assesses its supply chain companies using metrics such as delivery quality and timeliness. However, what ThundeRobot values most is their innovation capacities. It collaborates with its supply chain to design and produce differentiated products, like mechanical keyboards, which receive a significant welcome from customers.

Concerning the business cooperation aspect, we can glean insights from the application of the BSC in corporate alliances among companies. This approach prioritizes strategic congruence, shared metrics, and operational initiatives over contractual cooperation clauses.[12] As the business environment and competition continue to evolve, corporate alliances with relatively fixed cooperation clauses may soon find their joint practices becoming obsolete. However, shared values and aligned strategies can anchor their common interests at an acceptable level.

Take Xiaomi as an example. This company has implemented the ecological chain strategy to invest in and incubate a range of startups. Relying on its success in the smartphone market, Xiaomi takes minority stakes and provides comprehensive support in product development, quality control, fundraising, supply chain management, branding, and industrial design. In return, the ecological chain companies develop and manufacture goods under Xiaomi's brands, supplementing Xiaomi's IoT products mix. The number of partner companies increased from zero to 77 in later 2016, further surging to 210 in early 2018. Collectively, these ecological chain companies create synergies and contribute to Xiaomi's IoT infrastructure and product offerings. According to Xiaomi's prospectus, the gross margin of ecological chain products surpassed that of Xiaomi's own products in the IoT and Household Supplies Segment. Furthermore, Xiaomi's client acquisition cost for its internet services was lower than that of other major

[12] Kaplan, R.S., Norton, D.P. and Rugelsjoen, B. (2010) 'Managing Alliances with the Balanced Scorecard', Harvard Business Review, January.

internet competitors, thanks to its popular hardware products. Importantly, the products of ecological partners could attract a significant customer segment — iPhone users.[13] Without sharing controls, the corporate alliances between Xiaomi and ecological chain companies are fundamentally built on shared value and aligned strategy.

Both users and complementors serve as performance drivers for the infrastructure efficiency objective. As such, the metrics for this objective intersect with those of the other two objectives, such as customer complaint rate. However, this objective can also have independent metrics. One key indicator can be popularity, which could be gauged through metrics like the number of active IoT devices, developers, users, or the gross transaction volume within the ecosystem. The ecosystem infrastructure establishes standards for participants, thus guiding resource allocations. It is crucial to introduce metrics to measure the consumption of the ecosystem's "public goods or resources" by users and complementors. In this context, user consumption pertains to the cost to serve and customer profitability analysis, where complementor consumption refers to the cost to deliver and complementor contribution analysis. An ecosystem is unlikely to flourish if its participants bear disproportionately high costs relative to their revenues. •

[13] Xiaomi's mobile phones operate on customized systems, which are based on Android.

CONCLUSION

The characteristics of IoT products, combined with relevant technological advancements, present new opportunities for differentiation for businesses. One such opportunity is the IoT ecosystem. Comprising three layers — infrastructure, application, and platform — the ecosystem business model can create unparalleled competitive advantages for the platform owner. These advantages arise from network effects, the shortened user feedback loop, and efficient resource allocation. This is accomplished by allying with a selected range of complementary companies, offering an array of diverse, custom, and interconnected product mixes, and transitioning one-time transactional customers into cross-over users.

The transformation from a traditional business model to an IoT ecosystem can only be successful with suitable revenue measurement and performance evaluation. In revenue measurement, the platform owner should differentiate among one-time direct users, recurring direct users, and cross-over users, considering their embedded relationships with the IoT ecosystem. For performance evaluation, the platform owner should utilize a comprehensive framework that includes objectives for user engagement, platform infrastructure, and complementor engagement. Metrics that illustrate the causal relationship between performance drivers and performance should be developed and utilized.

Based on our analysis, we propose the following three initiatives for the platform owner to cultivate a thriving and sustainable IoT ecosystem:

Initiative 1: Enhance User Acquisition, Retention, and Engagement

The advent of data-driven IoT ecosystems has unquestionably accelerated the evolution of a personalized community economy. On the one hand, the user data gathered by the IoT ecosystem, which expands exponentially over time, can inform companies about customer needs. Conversely, through real-time data collection and analysis, businesses can offer more targeted and personalized features to their users, fully leveraging the power of network effects.

Initiative 2: Improve Entry Criteria, Support Systems, and Exit Mechanism for Partners

The platform owner should establish clear entry and exit mechanisms and collaborate with high-quality partners to ensure effective cooperation. It should also allocate resources to attract and support complementors, such as by providing technical services and developing toolkits. This dynamic support system will capitalize on the strengths of each partner and foster ecosystem co-creation.

Initiative 3: Create and Enhance Synergies

To maximize the ecosystem's value, the platform owner needs to pay closer attention to the platform's growth capability. The platform owner must recognize that the co-evolution of all participants is crucial for the ecosystem's sustainable development. It should encourage the propagation of best internal practices within the ecosystem, particularly in the areas of product development, marketing, and customer services, leading to a more prosperous IoT ecosystem. •

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