Research-Technology Management

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/urtm20

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To cite this article: Claudio Lamprecht, Heiko Gebauer, Elgar Fleisch & Felix Wortmann (2022) A KPI Set for Steering the IoT Business in Product Companies, Research-Technology Management, 65:2, 53-63, DOI: 10.1080/08956308.2022.2015951

To link to this article: https://doi.org/10.1080/08956308.2022.2015951

A KPI Set for Steering the IoT Business in Product Companies

Product companies can use the key performance indicators set presented here to manage their Internet of Things business effectively and avoid three pivotal measurement traps.

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OVERVIEW: The Internet of Things (IoT) offers product companies the opportunity to develop an IoT business. Existing performance measurement systems (PMS) are unsuitable for measuring and managing the business logic of IoT business. Based on research conducted with 31 product companies, we present three measurement traps, a key performance indicators (KPI) set suited for steering IoT business in product companies, and three recommendations for implementing the KPI set. Companies can use the KPI set to manage their IoT businesses more effectively and avoid the measurement traps.

KEYWORDS: Internet of Things, Performance management, Performance measurement system, Key performance indicators, Performance metrics

The Internet of Things (IoT) is a technological vision that foresees that any product could become smart and connected to the Internet. Such smart, connected products let product companies extend their physical product and services offerings toward digital offerings—for example, digital services and software applications. Such digital offerings embrace more service-centric business models associated with letting customers pay for product usage, performance, or outcome, and/or subscribing to the offering rather than buying the product (Gebauer et al. 2020; Paschou et al. 2020). Thus digital services transform revenue structures in product companies from non-recurring revenues into recurring revenues.

Bosch's e-bikes, Google's security cameras, and Michelin's tires are three illustrative examples of smart, connected products opening up IoT business opportunities. Bosch leverages the smart, connectable on-board computers of its e-bikes to offer digital navigation services to individual bike users or bike-sharing providers. Through connecting its security cameras to a cloud storage, Google offers customers the option of subscribing to its digital service to record and store security videos. By making its tires smart and connected, Michelin can track the actual tire usage of truck operators. These precise tire usage data allow Michelin to let truck operators pay only for the miles the tires run rather than having to buy the actual tires.

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DOI: 10.1080/08956308.2022.2015951

Beyond such illustrative examples, more general predictions suggest that there will be about 150 billion connected products and a possible annual revenue of USD $1.1 trillion generated through (digital) services as of 2025 (Columbus 2018; GSMA Intelligence 2018). Despite such opportunities, developing IoT businesses have had mixed results at best. While a few companies such as Schneider Electric, Hitachi, and Cisco have grown their new IoT businesses to about 15–25 percent of their total business, most companies struggle with IoT business development.

As with any business effort, performance measurement systems (PMS) are an important key success factor (Neely, Gregory, and Platts 2005). PMS combine important performance indicators to make a company's strategy tangible and measurable (Bititci et al. 2012). IoT business embraces a new logic of doing business, making new PMS necessary (Nudurupati, Tebboune, and Hardman 2016; Wolcott 2016). Existing PMS lack suitable and concrete measures to track the progress of individual IoT projects and/or the development of the IoT business. Recent surveys support this argument (Harvard Business Review Analytic Services 2019; Raskino 2017). One recent survey (n = 359), for instance, showed that 75 percent of the participating executives recognized that their existing PMS requires modifications to successfully steer the IoT business (Raskino 2017). Existing PMS might even mislead companies in developing their IoT business and cause managers to drive the wrong actions in their IoT initiatives (Melnyk et al. 2013; Wolcott 2016).

Until now, companies have used a few individual measures—for example, recurring revenue, usage metrics, or churn rate—to manage their IoT business (Heinis, Loy, and Meboldt 2018; Hui 2014; Schrage and Kiron 2018). A complete key performance indicator (KPI) set to steer the multifaceted and complex development of the IoT business is still missing (Nudurupati, Tebboune, and Hardman 2016). Based on an investigation of 31 companies, this article presents three key insights into measuring the IoT business: measurement traps that can emerge when steering the IoT business, a suitable KPI set, and recommendations for implementing the KPI set. The KPI set is a set of recommended performance indicators that companies can adapt to steer their IoT business.

Why Should Companies Introduce Measures for their IoT Business?

By investing in the IoT, companies make their products smart and connected, and enable data exchange between product providers and customers as product users (Euchner 2018). Companies can process data and create novel digital services (Lerch and Gotsch 2015). These digital services accelerate the shift from pure product-centric to more service-centric business models in product companies (Parida et al. 2014; Porter and Heppelmann 2015). The emerging IoT with its digital offerings opens up new business opportunities and additional revenue streams (Iansiti and Lakhani 2014). In addition, the IoT lets product companies get closer to customers, glean valuable insights from connected products' data regarding customer needs, and offer customized solutions for these needs (Rymaszewska, Helo, and Gunasekaran 2017). IoT is becoming an important way to achieve sustainable competitive advantages.

Attracted by these IoT benefits, many product companies have made IoT business a strategic initiative, experimenting first with new possible IoT business ideas and digital services. These experiments often gain momentum and become an additional business.

As with any business, a PMS is key to effectively and efficiently managing the IoT business (Neely 2005). In general, a PMS brings together individual KPIs across multiple dimensions to capture an aggregate of a company's performance (Bititci et al. 2012). But existing PMS in product companies are not suitable to steering the emerging IoT businesses (Nudurupati et al. 2011; Nudurupati, Tebboune, and Hardman 2016). Existing PMS rarely capture important indicators for IoT business models—for example, recurring revenue, net promotor score, usage metrics, or churn rate—nor do they capture the logic behind the IoT business. The balanced scorecard as a popular PMS supports the logic that better financial performance results from higher customer satisfaction and loyalty, which, in turn, are triggered by improving companies' learning and internal process indicators (Kaplan and Norton 1996). The logic of IoT business is different because it is essentially about getting products connected, receiving data about product usage, and then turning these data into digital offerings and getting customers to pay for the digital offerings to generate additional revenues (Rymaszewska, Helo, and Gunasekaran 2017). Thus, our goal is to create a KPI set for the IoT business that companies can adapt to steer their IoT business.

Method

We relied on qualitative research to gain insights about PMS for the IoT business (Eisenhardt and Graebner 2007). Our research process comprised two steps: an explorative study and an in-depth study. The explorative study helped to identify measurement traps that make it difficult to steer the IoT business and to highlight relevant KPIs. The in-depth study was set up to deepen insights into the KPI set for the IoT business and its implementation.

Explorative Study

Twenty-six companies participated in our explorative study. We collected data through interviews and company workshops (Table 1). We analyzed the interview transcripts and workshop protocols with a content analysis procedure that yielded three common measurement traps and an initial set of 35 possible KPIs to steer the IoT business (Table 2).

In-depth Study

Five purposively selected companies participated in our in-depth study. Three criteria guided the company selection: 1) Is the company actively pursuing IoT business?; 2) Does the company operate in an important IoT sector (for example, mobility, industry, or building) (Jankowski 2014)?; and 3) Does the company provide access to necessary key informants?

TABLE 1. Explorative study interviews

#	Company Pseudonym	Sales and Headquarters	Date	Participants
1	Surveying and indoor mapping provider	Sales: €30 million Headquarters: Germany	December 2018	Chief Executive Officer
2	Yarn and fiber processing equipment provider	Sales: €1.1 billion Headquarters: Switzerland	December 2018	Vice President Technology Center
3	Consultancy specialized in technology change	Sales: $7.5 billion Headquarters: United States	January 2019	Senior Manager
			January 2019	Senior Manager IoT
4	Technology and software provider	Sales: $110 billion Headquarters: United States	February 2019	EMEA Group Finance Lead
5	Conglomerate company/industrial equipment	Sales: €83 billion Headquarters: Germany	February 2019	Head of Platform Business
6	Filtration system provider	Sales: €3.9 billion Headquarters: Germany	February 2019	Chief Technology Officer
7	Digital platform and software provider	Sales: $2 million Headquarters: United States	February 2019	Director
8	Non-alcoholic beverage provider	Sales: $32 billion Headquarters: United States	February 2019	Board Member
9	Surveying and engineering equipment provider	Sales: €3.8 billion Headquarters: Switzerland	February 2019	Head of IoT
10	E-commerce and cloud computing company	Sales: $230 billion Headquarters: United States	February 2019	Global Lead Industrial Software
11	Industrial machine provider	Sales: €3.6 billion Headquarters: Germany	February 2019	Assistant to the Board
12	Industrial automation system provider	Sales: 4.1 billion CHF Headquarters: Switzerland	February 2019	Industry 4.0 Architect
13	Heavy equipment manufacturer	Sales: $38 billion Headquarters: United States	February 2019	Workshop: 30 participants
14	Conglomerate company/steel production	Sales: €41 billion Headquarters: Germany	February 2019	Workshop: 29 participants
15	Optical system and medical device provider	Sales: €5.8 billion Headquarters: Germany	February 2019	Workshop: 7 participants
			March 2019	Workshop: 7 participants
16	Industrial equipment manufacturer	Sales: €9.8 billion Headquarters: Switzerland	March 2019	Head of eBusiness
17	Private equity company	Sales: €900 million Headquarters: France	March 2019	Senior Investment Director
18	Hydraulic lifting solution provider	Sales: €1.1 billion Headquarters: Austria	March 2019	Team Lead IoT & Data Science
19	Engineering and technology company	Sales: €77 billion Headquarters: Germany	March 2019	CTO IoT Platform
20	Food processing business	Sales: 3.3 billion CHF Headquarters: Switzerland	March 2019	Workshop: 36 participants
			August 2019	Digital Service
21	Home appliance manufacturer	Sales: 1.1 billion CHF Headquarters: Switzerland	April 2019	Chief Technology Officer
22	Component manufacturer for energy systems	Sales: €25 billion Headquarters: France	July 2019	Head of Business Development
23	Farming equipment provider	Sales: €3.8 billion Headquarters: Germany	June 2019	Head of Platform Business
24	Automation equipment provider	Sales: €86.8 billion Headquarters: Germany	June 2019	Sales Manager
25	Communications equipment provider	Sales: $50 billion Headquarters: United States	August 2019	Digital Officer
26	Building technology business	Sales: $35 billion Headquarters: United States	August 2020	IoT Expert

TABLE 2. Initial set of IoT KPIs

#	IoT KPIs
1	Number/ratio of products sold that are connectable
2	Number/ratio of products sold that are connected
3	Number/ratio of products connected before and after warranty
4	Number/ratio of products that are connected with registered users (billable users)
5	Number/ratio of registered users
6	Number of new registered users
7	Number of app downloads
8	Daily active users (DAU)
9	Monthly active users (MAU)
10	DAU/MAU
11	New service subscribers
12	Total service subscribers
13	Customer lifetime value
14	Churn rate
15	Net promoter score
16	App ratings
17	Conversion rate (from free to premium)
18	Conversion rate (from products to service)
19	Service usage rate
20	Number of employees working on IoT projects
21	Number of open IoT jobs
22	Uptime
23	First time fix rate
24	Switching costs
25	Number of ecosystem partners
26	Revenue generated with ecosystem partners
27	Number of ecosystem interactions
28	New ecosystem users/products
29	IoT revenue
30	IoT revenue profitability
31	Share of IoT revenue (IoT revenue/total revenue)
32	Monthly recurring revenue (MRR)
33	Annual recurring revenue (ARR)
34	Average monthly IoT revenue per user
35	Degree of fulfillment IoT business case

We opted for an inductive case study design (Eisenhardt 1989) with a set of semi-structured interviews of 1 to 2 hours as a primary source of data (Table 3). We conducted 32 interviews with various relevant functions and hierarchical levels across the five cases. We interviewed, for example, chief financial officers, chief digital officers, presidents, vice presidents, controllers, and service managers. The interview guidelines comprised three parts: 1) general experience with the 35 possible KPIs revealed in the explorative study; 2) relevant KPIs for steering the IoT business; and 3) obstacles during implementation of the KPI set.

We compiled multiple interviews from one company into a case study description about KPIs for steering the IoT business. We manually coded the verbatim transcribed interviews by applying open coding (Flick 1998) to identify the recommended KPIs and identify traps and how to avoid them. We then grouped similar codes using axial coding to determine more abstract categories (Strauss and Corbin 1990). Accordingly, we analyzed these case study descriptions through a content analysis procedure starting with a within-case analysis and then a cross-case analysis. This procedure first identified the relationships between KPIs and then categorized these measures into more abstract categories. For example, the KPIs "Net promoter score," "Service usage rate," "Conversion rate," and "Churn rate" got categorized into the more abstract perspective "Do our customers adopt the digital services?" This content analysis led to a KPI set combining four perspectives with multiple indicators.

To observe how the KPI set functions in day-to-day work, we also observed the implementation efforts in the companies we studied. These observations helped us to learn how companies implement and use the KPI set. As a final step, we validated the KPI set by presenting and discussing it with academics and other practitioners in small-scale seminars.

Measurement Traps when Steering IoT Business

Peter Drucker's famous statement, "You can't manage what you can't measure," suggests that companies can only manage the IoT business effectively when they can measure it. When they began to measure the IoT business, our explorative study revealed three common measurement traps (Table 4). When companies fall into these traps, their IoT measures can become dysfunctional, which can lead to managers pursuing the wrong actions or making ill-informed choices.

Trap 1: Measuring IoT Business with a Product-Centric PMS

Measuring IoT business with a product-centric PMS raises barriers that can inhibit IoT business models. Pure

TABLE 3. In-depth study interviews

In-depth Case Companies	Sales and Headquarters	#	Date	Participant Background
Case A: Automotive supplier A world-leading automotive supplier, with activities reaching from powertrain peripherals, injection technology, and electrified mobility to connectivity-enabled mobility and vehicle services. The company has a strategic priority on providing smart mobility solutions through seamlessly connecting users and vehicles.	Sales: €48 billion Headquarters: Germany	A1	March 2019	Executive Vice President
		A2	March 2019	President
		A3	March 2019	Chief Financial Officer
		A4	April 2019	Chief Digital Officer
		A5	April 2019	Head Portfolio Management
		A6	August 2019	Executive Vice President
		A7	September 2019	Managing Director
		A8	November 2019	Managing Director
Case B: Hydraulic system provider A global operating and leading specialist for industry automation. Their portfolio includes hydraulic and electric solutions. They prioritize software solutions and their interfaces to the IoT for Industry 4.0 use cases.	Sales: €7.5 billion Headquarters: Germany	B9	March 2019	President
		B10	April 2019	Vice President Engineering
		B11	July 2019	Industry 4.0 Expert
		B12	August 2019	Industry 4.0 Technical Sales
		B13	November 2019	Managing Director
Case C: Home appliance provider A world-leading company for consumer goods. The portfolio covers household appliances, ranging from refrigerators to coffee machines. The company leverages IoT technology for smart home applications and services.	Sales: €18 billion Headquarters: Germany	C14	March 2019	Head of Digital Transformation
		C15	March 2019	Owner Digital Offerings (IoT); Business Owner Digital Business
		C16	May 2019	Chief Digital Officer
		C17	August 2019	Managing Director IoT Services
		C18	November 2019	Managing Director
Case D: Heating and security system provider A leading provider of security, communications, and energy management solutions for commercial and industrial buildings. The company offers smart home solutions (web-enabled and app-controlled) for heating and air conditioning, as well as room monitoring through surveillance cameras, motion, and fire detectors.	Sales: €5.6 billion Headquarters: Germany	D19	March 2019	Senior Vice President Integrator Business Europe
		D20	April 2019	Director Business Strategy
		D21	April 2019	Director Business Development
		D22	May 2019	Director Controlling
		D23	May 2019	Senior Vice President
		D24	May 2019	Team Leader Global Key Account Management
		D25	July 2019	Executive Assistant to the Board of Management; System Architect
		D26	November 2019	Managing Director
Case E: Machine manufacturer A leading global industrial machining solutions provider specializing in the safe transpiration of liquids and gases, high-precision manufacturing processes, and lightweight casting elements.	Sales: €4.1 billion Headquarters: Switzerland	E27	April 2019	President
		E28	April 2019	Sales Manager
		E29	April 2019	Strategic Marketing
		E30	April 2019	Chief Digital Officer
		E31	April 2019	Digital Service Designer
		E32	May 2019	Managing Director

product-centric financial metrics can prevent the launch of IoT business models. One company in our study is an automotive supplier that sells diagnostic tools and spare parts to car repair shops. The company realized it could significantly increase spare part sales by leveraging its diagnostic tool connectivity so customers could order the needed spare parts directly. As the executive vice president explained, "Thus, we planned to provide car repair shops with free 'connected' diagnostic tools and earn our money only with the spare parts sales. Despite being beneficial in the long run, our controllers rejected this business model . . . because of the financial targets we had to reach this year. Costing us valuable

Measuring IoT business with a product-centric PMS raises barriers that can inhibit IoT business models. Pure product-centric financial metrics can prevent the launch of IoT business models.

TABLE 4. Three common traps

Traps	Representative Quotations	Frequency Across Study Cases
Trap 1: Measuring IoT business with a product-centric PMS	• "We realized that we need an entirely new set of KPIs to manage our IoT business. Simply adding one or two IoT KPIs to the existing KPIs doesn't work."—CTO, filtration system provider • "The business logic of our IoT business is entirely different from that of our traditional business. . . . To measure and manage it, we introduced dedicated new KPIs. The existing product-centric KPIs would not only have been meaningless but would also have prevented the IoT business from flourishing."—Assistant to the Board, industrial machine provider • "We can leverage diagnostic tool connectivity to let customers order the needed spare parts directly with the diagnostic tool. With this direct link to the customer, we can significantly increase our spare parts sales . . . Thus, we planned to provide . . . free 'connected' diagnostic tools and earn our money only with the spare parts sales. . . . our controllers rejected this business model . . . because of the financial targets . . . Costing us valuable time, during which a competitor . . . occupied 3,000 workshops with its diagnostic tools."—Executive VP, automotive supplier	26/31
Trap 2: Only measuring "lagging" KPIs	• "We need to measure the whole continuum. We can't just look at financials. We need leading KPIs that capture the key drivers of our IoT business."—Managing Director IoT Services, home appliance provider • "We invest in connecting our laundry machines and developing services like the automated ordering of detergent. We will only earn money with these services if customers continue to use them for years to come. With today's PMS designed to track costs and sales of laundry machines, we miss, for example, analyzing whether customers are starting to use services less, which may indicate they are about to terminate the subscription."—Managing Director, home appliance provider • "Our current PMS does not include leading indicators like user activity, conversion rate, or churn rate. Without these metrics, we are practically flying blind with our IoT business."—Chief Digital Officer, machine manufacturer	26/31
Trap 3: Excluding important but "hard to measure" KPIs	• "At first, we did not consider the net promoter score [NPS] because measuring it is not easy and [is] costly. But we realized that it is a crucial metric for our IoT business. That's why we are now developing ways to measure the NPS efficiently."—CTO IoT Platform, engineering and technology company • "The NPS was considered too time-consuming since we could not simply query it. But we quickly realized that we were missing direct feedback from customers for our new services."—Digital Service Designer, machine manufacturer • "From a technical perspective, we have access, but we lack the customer's consent that allows us to use customer usage data. We should have simply obtained the consent in the general terms and conditions, just like all the software companies do."—System Architect, heating and security system provider	11/31

time, during which a competitor had already occupied 3,000 workshops with its diagnostic tools."

Why is that? The core business model in product companies is still selling products. However, IoT business requires more service-centric business models. Instead of selling a product, a company provides the product for free and the customer only pays for product usage—for example, no upfront payment but recurring payments over the product lifecycle. Financial metrics that push strongly for direct revenue or positive cash flow favor customers paying one time, but these metrics become suboptimal and dysfunctional under recurring revenue models because these metrics may provide faulty insights and lead to the wrong actions (Allmendinger and Lombreglia 2005). Companies might be trapped in their product-oriented PMS, preventing active sales of digital services that develop the IoT business. Companies can only overcome this trap by adjusting their financial metrics to value recurring revenues. The home appliance provider in our study, for example, included a new category for (recurring and/or digital) revenues in its financial metrics.

Trap 2: Only Measuring "Lagging" KPIs

Once the product companies began to adjust their financial metrics, some reported falling into the trap of focusing too much on "lagging" indicators such as revenues, profit, and annual recurring revenue (ARR). Digital and recurring revenues are the result of convincing customers to use the digital service, to switch from a free to a billable service level, to subscribe to upgrades, and so on. By not considering leading metrics like active users, conversion rate, and customer satisfaction, companies miss opportunities to respond to immediate challenges (Kaplan and Norton 1996). In addition, these IoT business–specific leading indicators go beyond the leading indicators previously used by product companies (for example, production costs, manufacturing error rates, or inventory turnover). The managing director of a home appliance provider explained that companies want new leading indicators for their IoT businesses. He said, "We invest in connecting our laundry machines and developing services like the automated ordering of detergent. We will only earn money with these services if customers continue to use them

for years to come. With today's PMS designed to track costs and sales of laundry machines, we miss, for example, analyzing whether customers are starting to use services less, which may indicate they are about to terminate their subscription."

Companies can avoid the trap of only measuring lagging indicators by balancing leading and lagging measures for their IoT business. By doing so, companies can effectively pursue long-term objectives while also being responsive to short-term challenges (Kaplan and Norton 1996).

Trap 3: Excluding Important but "Hard to Measure" KPIs

When product companies start to focus on IoT business-specific leading indicators, some quickly recognize that some of these indicators are easy to measure while others are hard to measure. For example, churn rate, in terms of how many customers terminate the digital service, is easy to measure, whereas a net promoter score (NPS) is more difficult to measure (Reichheld 2003). An NPS, as a customer satisfaction score, would indicate how many customers would recommend the digital service to other customers. If many customers would recommend it, then customers seem very satisfied with the digital services, which in turn increases customer retention and loyalty. Measuring the NPS is difficult since digital services create various touchpoints along the customer life cycle. It is not sufficient to measure the NPS only at one of these customer touchpoints—it must be consistently measured along the entire customer life cycle. The NPS benefits outweigh the high measurement effort, as the CTO of IoT Platform, at an engineering and technology company, explained, "At first, we did not consider the net promoter score because measuring it is not easy and [is] costly. But we realized that it is a crucial metric for our IoT business. That's why we are now developing ways to measure the NPS efficiently."

Tracking customer usage of the digital services is another measure companies can use as a proxy for customer satisfaction: if customers use a digital service frequently, they are likely satisfied with the service. While this sounds rational, there are two reasons why companies seldom use this measure: their existing IT systems cannot provide the necessary data points, and customers do not consent to having their usage data tracked. A systems architect with a heating and security system provider said, "From a technical perspective, we have access, but we lack the customer's consent that allows us to use customer usage data. We should have simply obtained the consent in the general terms and conditions, just like all the software companies do."

If companies do not include these harder, more effortful, and complex-to-measure performance indicators, they often miss important KPIs to steer their IoT business (Schrage and Kiron 2018).

A KPI Set for the IoT Business

Moving beyond the three measurement traps leads to a holistic set of KPIs for the IoT business that addresses four key questions:

1. Are our products getting connected?
2. Do our customers adopt the digital services?
3. Do we have a viable ecosystem for developing the IoT business?
4. Do we make sustainable profits in the IoT business?

These four questions are the four core perspectives within the KPI set. Our in-depth study revealed 12 performance indicators that help managers answer these questions. We have grouped them under the four questions.

Are Our Products Getting Connected?

This perspective captures three KPIs to track product connectivity as a basis for developing the IoT business.

KPI #1: IoT-enabled products sold—To understand IoT business opportunities, companies must measure how many of today's products are actually IoT-enabled through software, sensors, actuators, and connectivity components. IoT enablement can include new products sold to the customer or products that are already installed that can be reconfigured and/or retrofitted to become IoT-enabled. Since making products IoT-enabled comes with certain costs, this metric is especially relevant when the IoT components are not included in products by default. Companies need to understand the share of customers actively choosing the IoT components, but IoT-enabled products do not automatically mean that customers also become connected or that users actually register. Measuring the IoT-enabled products is just an approximation of a company's IoT costs; only through metrics on how many IoT-enabled products become connected and for how many of these connected products customers actually register, can companies better estimate the business opportunity for digital services.

KPI #2: Connected products—The interviewees mentioned the importance of measuring connected products because they represent a product company's physical access points to the digital world. For example, for the home appliance provider, dishwashers and washing machines only provide the necessary data points for IoT services, such as the automatic replenishment of detergent or dishwasher tabs, when they are connected.

When product companies start to focus on leading indicators, some quickly recognize that some of these indicators are easy to measure while others are hard to measure.

The business value of IoT lies in leveraging the data from connected products for (digital) services that solve customer needs.

KPI #3: Registered users—The interviewees stressed the importance of measuring registered users, since IoT services can only be sold if companies "know" the customer behind the connected products. Knowing a customer means that customers have provided their contact details and their payment details.

Do Our Customers Adopt the Digital Services?

The first perspective incorporates the recommended KPIs that measure enabling IoT. However, connected products alone only generate costs. Customers are not willing to pay more merely for IoT-enabled products, and there are ongoing operating costs for maintaining connectivity and data processing. The business value of IoT lies in leveraging the data from connected products for (digital) services that solve customer needs. Hence, interviewees recommended metrics that follow the objective to measure whether customers adopt services.

KPI #4: Active users—The interviewees mentioned measuring how many users (or customers) are actively using a service as a way of capturing the success of a service. The chosen metric was either daily active users (DAU) or monthly active users (MAU), depending on the type of service and the respective typical usage frequency.

KPI #5: Net promoter score (NPS)—Study participants considered the NPS, or related metrics, such as the customer satisfaction score (CSAT), necessary to understand how satisfied customers are. Only satisfied customers are likely to continue using and paying for services and thus generate profits for the company. Companies can collect the NPS using a survey in which customers are asked to answer the question, "How likely are you to recommend our service to a friend?" on a scale of 1 to 10 (Reichheld 2003). Similarly, with the CSAT, customers are asked to rate their satisfaction with a service typically on a scale of 1 to 5 (Marr 2012). The average rating of all customer responses is then the NPS or the CSAT score.

KPI #6: Conversion rate—This metric captures the success rate of turning potential customers into paying customers. The study participants pointed out that "freemium" or "free trial" become important business models in the IoT business. Freemium entails offering a basic service free of charge but charging money for a premium service. Free trial means customers can use the service free of charge for a limited period. The basic premise behind both strategies is to convince customers to sign up for a free version and to subsequently convert them into paying customers. The conversion rate captures the effectiveness of this strategy and thus becomes an important metric to measure IoT business. The conversion rate is also suitable for tracking upgrades and downgrades for IoT services, making it possible to track increases and losses of revenues.

KPI #7: Churn rate—The study participants emphasized that IoT-driven business models usually pay off over time, as they often involve revenue models where smaller fees are collected over time through a subscription or a pay-per-X. Thus, customer retention becomes a key success factor. For instance, the head of digital transformation of the home appliance provider pointed out that their home appliance subscription has a minimum contract term of three months, but profitability will only be achieved if customers remain subscribers for years. The study participants recommended measuring customer retention through the churn rate, which is the percentage of customers lost over a particular period.

Do We Have a Viable Ecosystem for Developing the IoT Business?

A single company is not capable of developing all of the necessary elements for the IoT business (Jacobides 2019). A company needs a viable business ecosystem that consists of various complementary partners. Two KPIs help to steer the viability of the ecosystem.

KPI #8: Ecosystem partners—Companies can track the number of partners in the ecosystem. In the e-bike business with e-bike manufacturers, private e-bike users, and bike sharing providers, the participating company recognized that it was strong in providing connected onboard computers for e-bikes, but mapping services using the GPS data from the e-bikes' onboard computers was beyond its competencies. Such mapping services are important for bike sharing companies since they make it easy for e-bike users to find the closest available e-bike. The e-bike business needs complementary partners with expertise in developing such mapping and navigation services for bike sharing providers and e-bike users. The company decided to measure the number of ecosystem partners contributing to the IoT business.

KPI #9: Interactions with ecosystem partners—Increasing the number of partners is just one part of building a viable business ecosystem; a second important part is tracking interactions with partners in the ecosystem. The more partners interact—for example, develop projects for digital services, sales, and usage of all partners' digital services—the stronger the partnerships. In the e-bike example, the company began tracking interactions with the mapping service provider by tracking how many e-bike rides its bike sharing customers actually booked through the partner's mapping and navigation application. The higher the number of e-bike users using the mapping service to search for the closest e-bike available for the next ride, and booking directly through the mapping service, the stronger the partnerships between the e-bike company, the bike sharing provider, and the mapping service provider. The ecosystem for developing the IoT business becomes more viable through stronger partnerships.

Do We Make Sustainable Profits in the IoT Business?
The interviewees also reported metrics that aim to capture the financial perspective of the IoT business.

KPI #10: IoT revenue—Investments in the IoT and the development of services only pay off if companies can achieve corresponding IoT revenues or cost savings. Companies record IoT revenue separately to track progress in the IoT business. The chief digital officer with a home appliance manufacturer explained that the company's goal is to drive revenue growth from IoT services such as an automatic detergent replenishment service. He said, "To track the progress, we specified IoT services as a separate revenues category compared to the classic services such as field services and product sales . . . Through this separate category for IoT services, we could formulate concrete strategic objectives to generate 5 percent of our total revenue with IoT services by 2025."

The ecosystem for developing the IoT business becomes more viable through stronger partnerships.

Measuring the IoT revenue creates three advantages. First, putting up IoT services as a separate revenue category avoids the tendency to give IoT services away for free to promote product sales (Ulaga and Michel 2019). Second, tracking the IoT revenues makes it easier to incentivize the sales force to market IoT services more actively. Third, companies can track

KPI Set for the IoT business		Automotive supplier	Home appliance provider	Machine manufacturer
Are our products getting connected?	• Sold IoT-enabled products	• App downloads	• Share of IoT-enabled products sold	
	• Connected products		• Share of connected products	• Number of connected machines during and post warranty
	• Registered users	• New registered users • Total registered users	• Number of products with account registration	• Share of products with service contracts
Do our customers adopt the digital services?	• Active users	• Active users this month	• Monthly active users	• Frequency of usage • Machine failures solved remotely
	• Net promoter score (NPS)	• App ratings average		• Machine availability of connected vs non-connected machines
	• Conversion rate	• Conversion rate from registered to active users		
	• Churn rate			• Renewal rate for service contracts and digital services
Do we have a viable ecosystem for developing the IoT business?	• Ecosystem partners	• Number of ecosystem partners		• Number of services offered through partners
	• Interactions with ecosystem partners	• New users from ecosystem	• Monthly active ecosystem partner users	
Do we make sustainable profits in the IoT business?	• IoT revenue	• IoT service revenue	• IoT service revenue	• IoT service revenue
	• Annual Recurring Revenue (ARR)	• ARR	• ARR	
	• Profitability of IoT revenue		• Profitability of IoT service revenue	• Gross margins

FIGURE 1. Derived KPI systems of three participating companies

the IoT revenue per customer, making it easier to assess whether customers start using and paying for more and more IoT services.

KPI #11: Annual recurring revenue—In addition to measuring IoT revenue, companies reported introducing ARR as a revenue category. ARR refers to the revenue that a company expects to receive from active customer contracts (subscriptions) plus revenues from new customers and upgrading services in the next year, minus revenue lost from customers expected to terminate their contracts and downgrading their service level during the year (Tzuo and Weisert 2018). ARR is, therefore, a metric to predict revenues, and serves to forecast future IoT revenues. Introducing ARR as a metric appeals to stakeholders and shareholders since it signals a constant revenue stream (Hui 2014).

KPI #12: Profitability—Companies also measure the profitability of the IoT business. Profitability measures help to ensure that the IoT business achieves the same or even a higher margin as the traditional business.

Implementing the KPI Set

Three recommendations emerged from our study about implementing the KPI set for the IoT business:

1. *Complement, do not replace.* The KPI set for the IoT business should not replace existing PMS. Introduce a dedicated IoT KPI set that complements existing KPI systems to avoid potential resistance to changing the established PMS.
2. *Make it simple, not complex.* Complementing existing KPI systems does not mean having a complex new KPI system. Start with a minimal viable KPI system for the IoT business. Test how these few KPIs help the company better manage the IoT business before integrating further metrics for the development and expansion of the IoT business.
3. *Change KPIs over time.* The KPI set simplifies the selection of relevant KPIs. Selected KPIs are not fixed and static but rather change over time. Depending on the stage in the expansion of the IoT business, KPIs such as "connected products" or "registered users" might become less relevant, and KPIs such as "ecosystem partners" or "profitability" might become more critical.

Having these three recommendations in mind leads to a KPI system for the IoT business (Figure 1).

Conclusion

IoT is a technological vision opening up new business opportunities beyond today's core business of product companies. As with any strategic growth initiative targeting new markets, IoT business requires a new set of KPIs. These KPIs differ from the existing PMS steered toward increasing efficiency and effectiveness in today's core business. Getting the right KPIs to let the IoT business flourish is difficult. Companies should be aware of possible measurement traps when measuring IoT business: measuring the IoT business with a product-centric PMS, only measuring "lagging" KPIs, and excluding important but "hard to measure" KPIs. When developing their IoT business, companies can use the set of 12 KPIs presented to answer four key questions related to connectivity, adoption of digital services, availability of a viable ecosystem for developing the IoT business, and sustainable profits. Following the three recommendations when implementing the KPI set will enable companies to ensure that IoT KPI systems complement existing PMS, that they are simple and not too complex, and that they change over time. By being aware of the measurement traps, adapting the KPI set, and implementing the recommendations, companies should find it easier to steer the IoT business.

This research was funded and supported by the Bosch IoT Lab at the University of St. Gallen & ETH Zürich.

References

Allmendinger, G., and Lombreglia, R. 2005. Four strategies for the age of smart services. *Harvard Business Review* 83(10): 131–145. https://hbr.org/2005/10/four-strategies-for-the-age-of-smart-services

Bititci, U., Garengo, P., Dörfler, V., and Nudurupati, S. 2012. Performance measurement: Challenges for tomorrow. *International Journal of Management Reviews* 14(3): 305–327. doi:10.1111/j.1468-2370.2011.00318.x

Columbus, L. 2018. 2018 Roundup of Internet of Things forecasts and market estimates. Forbes, December 13. https://www.forbes.com/sites/louiscolumbus/2018/12/13/2018-roundup-of-internet-of-things-forecasts-and-market-estimates/#35fdbdae7d83

Eisenhardt, K. M. 1989. Building theories from case study research. *Academy of Management Review* 14(4): 532–550. doi:10.5465/amr.1989.4308385

Eisenhardt, K. M., and Graebner, M. E. 2007. Theory building from cases: Opportunities and challenges. *Academy of Management Journal* 50(1): 25–32. doi:10.5465/amj.2007.24160888

Euchner, J. 2018. The Internet of Things. *Research-Technology Management* 61(5): 10–11. doi:10.1080/08956308.2018.1495971

Flick, U. 1998. *An Introduction to Qualitative Research*. 1st ed. London: Sage.

Gebauer, H., Arzt, A., Kohtamäki, M., Lamprecht, C., Parida, V., Witell, L., and Wortmann, F. 2020. How to convert digital offerings into revenue enhancement—Conceptualizing business model dynamics through explorative case studies. *Industrial Marketing Management* 91:429–441. doi:10.1016/j.indmarman.2020.10.006

GSMA Intelligence. 2018. Global IoT connections and revenue forecasts. May 30. https://www.gsma.com/newsroom/press-release/new-gsma-study-operators-must-look-beyond-connectivity-to-increase-share/

Harvard Business Review Analytic Services. 2019. Accelerating the Internet of Things timeline. *Pulse Survey,* May 30. https://hbr.org/sponsored/2019/05/accelerating-the-internet-of-things-timeline

Heinis, T. B., Loy, C. L., and Meboldt, M. 2018. Improving usage metrics for pay-per-use pricing with IoT technology and machine learning. *Research-Technology Management* 61(5): 32–40. doi:10.1080/08956308.2018.1495964

Hui, G. 2014. How the Internet of Things changes business models. *Harvard Business Review*, July 29. https://hbr.org/2014/07/how-the-internet-of-things-changes-business-models

Iansiti, M., and Lakhani, K. R. 2014. Digital ubiquity: How connections, sensors, and data are revolutionizing business. *Harvard Business Review* 92(11): 90–99. https://hbr.org/2014/11/digital-ubiquity-how-connections-sensors-and-data-are-revolutionizing-business

Jacobides, M. G. 2019. In the ecosystem economy, what's your strategy? *Harvard Business Review* 97(5): 128–137. https://hbr.org/2019/09/in-the-ecosystem-economy-whats-your-strategy

Jankowski, S. 2014. The sectors where the Internet of Things really matters. *Harvard Business Review*, October 22. https://hbr.org/2014/10/the-sectors-where-the-internet-of-things-really-matters

Kaplan, R. S., and Norton, D. P. 1996. Linking the balanced scorecard to strategy. *California Management Review* 39(1): 53–79. doi:10.2307/41165876

Lerch, C., and Gotsch, M. 2015. Digitalized product-service systems in manufacturing firms: A case study analysis. *Research-Technology Management* 58(5): 45–52. doi:10.5437/08956308X5805357

Marr, B. 2012. *Key Performance Indicators: The 75 Measures Every Manager Needs to Know*. Harlow, UK: Pearson.

Melnyk, S. A., Bititci, U., Platts, K., Tobias, J., and Andersen, B. 2013. Is performance measurement and management fit for the future? *Management Accounting Research* 25(2): 173–186. doi:10.1016/j.mar.2013.07.007

Neely, A. 2005. The evolution of performance measurement research: Developments in the last decade and a research agenda for the next. *International Journal of Operations & Production Management* 25(12): 1264–1277. doi:10.1108/01443570510633648

Neely, A., Gregory, M., and Platts, K. 2005. Performance measurement system design: A literature review and research agenda. *International Journal of Operations & Production Management* 25(12): 1228–1263. doi:10.1108/01443579510083622

Nudurupati, S. S., Bititci, U. S., Kumar, V., and Chan, F. T. S. 2011. State of the art literature review on performance measurement. *Computers & Industrial Engineering* 60(2): 279–290. doi:10.1016/j.cie.2010.11.010

Nudurupati, S. S., Tebboune, S., and Hardman, J. 2016. Contemporary performance measurement and management (PMM) in digital economies. *Production Planning & Control* 27(3): 226–235. doi:10.1080/09537287.2015.1092611

Parida, V., Sjödin, D. R., Wincent, J., and Kohtamäki, M. 2014. Mastering the transition to product-service provision: Insights into business models, learning activities, and capabilities. *Research-Technology Management* 57(3): 44–52. doi:10.5437/08956308X5703227

Paschou, T., Rapaccini, M., Adrodegari, F., and Saccani, N. 2020. Digital servitization in manufacturing: A systematic literature review and research agenda. *Industrial Marketing Management* 89:278–292. doi:10.1016/j.indmarman.2020.02.012

Porter, M. E., and Heppelmann, J. E. 2015. How smart, connected products are transforming companies. *Harvard Business Review* 93(10): 96–114. https://hbr.org/2015/10/how-smart-connected-products-are-transforming-companies

Raskino, M. 2017. 2017 CEO Survey: CIOs Must Scale Up Digital Business. Gartner, March 31. https://www.gartner.com/en/documents/3645407/2017-ceo-survey-cios-must-scale-up-digital-business

Reichheld, F. F. 2003. The One Number You Need to Grow. *Harvard Business Review* 81(12): 46–55. https://hbr.org/2003/12/the-one-number-you-need-to-grow

Rymaszewska, A., Helo, P., and Gunasekaran, A. 2017. IoT powered servitization of manufacturing—an exploratory case study. *International Journal of Production Economics* 192:92–105. doi:10.1016/j.ijpe.2017.02.016

Schrage, M., and Kiron, D. 2018. Leading with next-generation key performance indicators. *MIT Sloan Management Review,* June 16. https://sloanreview.mit.edu/wp-content/uploads/2018/06/9dbcc7b64e.pdf

Strauss, A., and Corbin, J. 1990. *Basics of Qualitative Research*. 1st ed. Newbury Park, CA: Sage Publications.

Tzuo, T., and Weisert, G. 2018. S*ubscribed: Why the Subscription Model Will Be Your Company's Future and What to Do About it*. 1st ed. New York, NY: Penguin.

Ulaga, W., and Michel, S. 2019. Bill it, kill it, or keep it free? *MIT Sloan Management Review* 60(2): 45–49. https://sloanreview.mit.edu/article/bill-it-kill-it-or-keep-it-free

Wolcott, R. C. 2016. Don't be tyrannized by old metrics. *Harvard Business Review,* September 23. https://hbr.org/2016/09/dont-be-tyrannized-by-old-metrics