Interactions between Traditional and Reversed IT Adoption: How Incumbent Devices affect Cross-Situational Specialization of New Entries

Christopher Agyapong Siaw, Jack Cadeaux, Dirk Meissner, Adrian Payne, and David Sarpong

Abstract— **This study proposes a cross-situational specialization framework for what, at its introduction, was a newer generation personal computer (PC) device (a tablet computer). With use as the basis for continuance adoption as the theoretical lens, this study explores how the tablet co-exists as a substitute- and a complement-in-use with incumbent PC(s). To test a model consisting of cross-situational use patterns, determinants, and outcomes, this study develops and analyzes the results of a survey of tablet computer use in a learning and education context. The results show a stronger co-existence between the tablet and the incumbent devices when the devices perform the same tasks in different, compared to the same, situations. Additionally, use of the PC devices as distinct units depends more on the situational sophistication of their features for use than sophistication of the devices per se. Further, user perception of the tablet's in-use impact depends on its performance in situations where the incumbent devices have limited sophistication, while user perception of the tablet as an essential device depends on its extension of the uses of the incumbent devices to different situations. This study implies that when a newer generation personal mobile device is an imperfect substitute for incumbent PC devices, individual adoption of such a mobile device may facilitate a partial reversal of IT adoption in organizations.**

Index Terms—**complementarity, substitution, systems, IT adoption, technology diffusion, use.**

I. INTRODUCTION

THE phenomenon of "bring your own device" (BYOD) permits individuals to use their own mobile devices for work and professional engagements in organizational settings [5]. BYOD has become even more attractive to organizations in recent times as result of the Covid-19 pandemic and its resultant effect on "working from home" (WFH) [57]. According to reference [22], organizations that favor BYOD save $350 per year, per employee annually, and the BYOD market was projected to grow from $30 billion in 2014 to almost $367 billion by 2022. On the one hand, BYOD facilitates resource optimization for organizations through reduced investment in new device acquisition, and it increases productivity because individuals/employees can work flexibly on mobile devices across situations other than organizational spaces of work. However, BYOD may pose security threats to organizational information technology (IT) systems, such as software, data, and other intellectual properties, when there are no restrictions on how personal devices apply to specific tasks in IT systems in situations uncontrollable by organizations.

So, the key question here is whether organizations should approve BYOD for unrestricted access to organizational IT systems in situations other than office spaces. If so, to what extent can the use of personal devices be maximized across situations without exposing organizational IT systems to security threats? The answers to the above questions are important not only for IT managers in organizations but also have important theoretical implications for the use of IT devices and systems as a function of technology diffusion [6], [60].

Scholarly research on the use of IT devices and systems as a function of technology diffusion emphasizes traditional IT adoption logic underpinned by diffusion theory [59] or the technology acceptance model (TAM) [17], [73] and the unified theory of acceptance and use of technology (UTAUT, UTAUT2) [74], [75]. With diffusion theory, IT adoption is determined by the acquisition, ownership, and replacement of units of technological devices with new ones (e.g., [7], [50], [41]). This approach to IT adoption might lead to an increased cost for organizations due to the replacement and disposal of incumbent devices, particularly considering the increasing speed of innovation of smart devices facilitated by the "internet of things" (IoT). However, in technology acceptance, IT adoption is determined by end-user perception (e.g., perceived ease of use and usefulness) and expectation (e.g., effort and performance expectancy) of the use of the IT system applications (e.g., software) of devices as a standardized system without the distinctions of the discrete applications of the IT system on devices [56], [71]. This approach to traditional IT adoption might lead to inefficiencies in the use of IT systems in organizations when there is an overlap in the use of the systems' applications for personal and organizational activities.

In view of the above issues underlying traditional IT adoption logic, some scholars have called for further research on reversed IT adoption logic in which liberal IT governance mechanisms allow organizations to integrate the individual adoption of personal mobile devices into the use of IT systems through BYOD [5], [42], [43], [44]. Reversed adoption may enable organizations to reduce the cost of investment in IT device acquisition in the long-term [6]. It may also generate significant cost efficiencies in IT investment when the addition of new devices reduces the per unit cost of technologies with space constraints (e.g., organization's Internet infrastructure) and technologies with ubiquitous access (e.g., cloud-based technologies) [8]. However, in the case of reversed adoption, when the use of organizational IT systems (e.g., software, data etc.) has no boundaries of space (e.g., office versus in-transit versus home situations) and tasks (e.g., access versus download versus upload) on personal devices, this might expose important corporate information in unauthorized situations. Therefore, while reversed adoption is crucial for organizational IT system governance, organizations must clearly distinguish between situations and tasks that may require personal versus organizational devices, and that is the reason for this research.

This study develops a cross-situational specialization (CSS) model to explain how the substitution for and complementarity between what at the time was a newer generation device, i.e., the tablet PC, and incumbent PC device(s) in-use affect, and are affected by, the evolution of the PC technology systems. An analysis of the CSS of use explains the circumstances in which two or more technological devices (e.g., desktop, laptop, tablet, e-reader, and smartphone) can be employed to perform the same set of tasks either sequentially or concurrently across different use situations. Understanding CSS is important to advance the knowledge on technology diffusion when use-diffusion of incumbent PC technologies facilitates the continuance adoption of newer generation related technologies [62], [63], which may serve as a substitute for incumbents but do so imperfectly and co-exist in use in different situations [26], [28]. Although CSS may occur at the micro-level of use, it has significant implications for the macro-level of adoption because of the symbiotic relationship between the use and the continuance adoption of technologies [9], [30], [66].

As an extension of Shih and Venkatesh's [62] use-diffusion model, this study contributes to the technology diffusion research by reconciling traditional and reversed IT adoption logics. In particular, the study shows that when newer generation personal mobile devices serve as a substitute for incumbent PC devices but do so imperfectly, continuation of the traditional adoption of IT devices by individual users may partially reverse IT adoption in organizations. This occurs when individuals employ both the newer generation personal device and the incumbent organizational device as substitutes and complements based on the situational sophistication of the attributes of the devices for organizational IT systems use rather than the sophistication of the devices per se.

This paper proceeds as follows. First, we review the literature on traditional and reversed IT adoption logics. Second, we present the research background to the new CSS framework and develop the associated hypotheses. Next, we describe the research methods, present the analysis, and outline our findings. Further, we discuss the theoretical and practical implications of the results. Finally, we draw a conclusion and highlight avenues for future research.

II. LITERATURE REVIEW: FROM TRADITIONAL IT ADOPTION TO REVERSED IT ADOPTION

Technology adoption remains one of the most long-standing areas of research in the literature of the diffusion of new technologies [7], [59]. However, recent developments in IT call for a clear distinction between devices and the systems embedded in devices [11], [53], [70]. Such a distinction is important to understand IT adoption when individual factors overlap with organizational factors to influence the diffusion of new technologies [24]. In the case of the diffusion of personal computer (PC) technologies, the relationship between organizational and individual factors is critical due to the evolving nature of PCs into personal mobile devices and the high adaptability of those devices to organizational IT systems [46], [60].

However, the traditional understanding of IT adoption involving individuals and organizations emphasizes a top-down perspective, in which, for instance, an organization's IT department identifies a need for, chooses, and acquires a new technology for the organizational actors, such as individual employees [34], [74]. Since the measure of IT adoption depends mainly on technology acquisition and ownership in this context, the constant replacement of earlier versions with newer versions of the technology remains a necessity to sustain adoption [16], [33], [37], [49], [50]. Despite the symbolic value in the acquisition and ownership of newer technologies for individuals [21], acquisition and ownership can be costly to organizational adopters if the rate of innovation is fast and the newer generation technologies only improve upon, rather than add new benefits to, the performance of older versions [45]. Thus, from an organization's perspective, the acquisition and ownership of devices per se may offer a limited understanding of IT adoption.

In contrast to the ownership view, but consistent with the traditional IT adoption logic, the TAM [17], UTAUT and UTAUT2 models [75] [20], [3], [56], [71] rather emphasize the use of the IT system applications of devices as a measure of IT adoption. While these models consider adoption based on individual use, rather than ownership, of IT systems predominantly in organizational contexts [5], they consider use as a qualitative experience based on user perceptions (e.g., TAM) and expectations (UTAUT and UTAUT2) of the generic or purposeful use of the IT systems embedded in devices. Although qualitative perceptions and expectations of IT system use facilitate an understanding of the process through which users adapt new technologies to their own use, they are limited in measuring IT adoption. This is particularly the case when the attributes of IT involve a bundle of device and IT system that facilitates the quantifiable rate, frequency, and variety of uses of the same or different attributes. Such quantifiable uses of attributes are important to understand how end-user acceptance of a technology may depend on the specific attributes of the device only, IT system only, or a bundle of device and IT system for personal and/or organizational uses. For organizations, it is important to discriminate between the attributes of IT devices and systems that must be owned or sourced externally when investing in IT infrastructure [48].

Nonetheless, in extending the understanding of traditional IT adoption to post-adoption use-diffusion, some scholars [62], [63], have examined how adopters of a PC as a bundle of device and IT system put the attributes of the PC into discernible patterns of rate and variety of use at home. Shih, Wu, Wang and Chen [64] have examined how use-diffusion of the attributes of the IT system, such as voice over Internet protocol (VoIP), facilitate rate and variety of use for individual users. From a traditional IT adoption perspective, use-diffusion remains essential for the continuance adoption of subsequent generations of the technology by distinguishing between the attributes of the technology, which can be limited to devices alone, systems alone, or both devices and systems. Such a distinction between the attributes of devices and IT systems may be understood when newer generation devices are embedded with the same IT system applications as incumbent devices but with differing levels of attribute sophistication in specific situations of use. For instance, while VoIP as an IT system may be accessed on a desktop PC device at home or at the office, it may be accessed on laptops, tablets, or even Smartphones while in-transit. Yet current research on the use-diffusion of attributes emphasizes the same type of PC device in a single use situation at home [62], [63] and a single IT system (VoIP) whose use is unrestricted to specific situations [64]. From an organizational IT adoption and governance perspective, when use of a technology is limited to a specific space or situation (e.g., at home or workplace) because of ownership or mobility issues associated with the technology, it affects productivity when end-users are out of that use space. Conversely, when use of a technology is not restricted to a particular space (e.g., through the Internet and cloud computing), it might increase productivity due to the universal accessibility of the technology. However, it exposes organizational IT systems to security threats in public and unauthorized spaces. Therefore, organizations must consider how interactions between time and space may require ownership or access to IT devices and systems to optimize the IT spending on existing and new generation technologies.

Optimizing the spending on existing and new generation technologies in organizations may lead to a reversed IT adoption in organizational settings where newer generation personal mobile devices might be integrated into the use of IT systems through BYOD [5], [42] [43], [44]. While BYOD may allow an individual to bring a personal device to a workplace or a professional setting, it can also allow an individual to use a personal device to work from either home or somewhere other than the workplace. However, current research on reversed IT adoption through BYOD does not clarify the extent to which different types of devices are a substitute for and complement one another for the same or different sets of tasks when users have access to different types of devices within and between situations for personal and organizational uses. This is important when there are imperfect substitutions between newer generation and incumbent devices [26] such that users might prefer devices based on the sophistication of attribute for use more than on the sophistication of the device per se [28]. This study adopts a use-diffusion framework to examine how the tablet PC, which, at its introduction, was a newer generation PC, co-exists as a substitute- and a complement-in-use with incumbent PC(s) in a higher education learning context.

III. THEORETICAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

Use-diffusion, which explains how adopters of a technology put the technology into discernible patterns of use, can be understood by comparing use behaviour from either a static perspective *at a particular time* [62], [64] or a dynamic perspective *across time* through the evolving use of the PC technology following its adoption [63]. However, dynamic use-diffusion emphasizes the continuous use of the PC technology in a single, but evolving, device. In contrast, static use-diffusion incorporates technology continuity in different devices and reveals that use of a home PC facilitates user interests in future technologies related to an incumbent device. Theoretically, user interests in future technologies related to incumbent ones can be examined from the perspectives of both the continuance adoption and use of new generation devices after adoption and the use of an incumbent one. However, research examines a sequential process in which adoption facilitates a continuance use of a new device as a replacement [9], [66], [30] rather than as an imperfect substitute for incumbent types of devices.

Drawing on the static use-diffusion framework, the study examines the relationship between the new and incumbent devices as part of a system of independent technologies and as distinct units in-use. The setting for this study is PC devices with screens in the context of learning and educational use including desktops, laptops, tablets, smartphones, and e-readers. However, a tablet computer[1] represents what, at its time of introduction, was a newer generation PC device, because this device had then been only recently widely adopted. The use of these devices in this context involves both software and hardware together. However, use may involve software alone when it is limited to software applications (or apps) of devices [23] or hardware alone when it is limited to, for instance, how users employ a keyboard, touchscreen, or mouse across these devices. We consider the devices as bundles of hardware and software systems that perform tasks across situations.

We extend the post-adoption static use-diffusion model to explain the continuance adoption and use of a tablet device following the earlier adoption and use of an incumbent PC device [62]. The static use-diffusion model derives four patterns of PC use from a cross-classification of high/low rates of use (e.g., weekly hours of use) and variety of use (e.g., number of different uses). These four patterns include intense, limited, specialized, and non-specialized use. Intense use depicts a high rate and a high variety of use whereas limited use depicts a low rate and a low variety of use. Specialized use involves a high rate but a low variety of use, while non-specialized use involves a low rate but a high variety of use.

This study extends the static use-diffusion model based on *specialized* and *non-specialized use patterns* because a specialized use represents an established pattern with incumbent devices by which newer generation devices can diffuse in-use as part of a system of interrelated PC technologies for the user [38], [76]. However, a non-specialized use represents a non-established pattern, by which attributes offer distinct uses of the devices as units [38], [77]. Thus, *specialized use* explains the integration of the new and incumbent devices *as part of IT systems* for the same types of use, but *non-specialized use* explains the use of the devices as *distinct units*. The two other patterns, intense and limited use, fall outside the scope of this research (but remain worthy of investigation in future research) because these two scenarios emphasize cross-device intensification or limitation of use whereas *the present research focuses on cross-situational specialization of use*. It should be noted that intense use represents established and non-established uses performed by a high variety of attributes at a high rate across new and incumbent devices, whereas limited use represents established

[1] The study distinguishes tablet computers from e-readers based on their functional purpose. We define a tablet as a PC that has a touchscreen but no legend keyboard. Although earlier examples existed, they had limited use, so we establish the beginning of the mainstream tablet computer adoption after Apple introduced the iPad device in 2010 [12].

and non-established uses performed by a low variety of attributes at a low rate across multiple devices.

In addition to how the devices apply to *specialized* and *non-specialized use,* our model differs from and extends the static use-diffusion model in two other important ways (see Fig. 1). First, the static model of Shih and Venkatesh [62] views the new device as a pioneering device and compares multiple users between households. Instead, we view the new device as an imperfect substitute for incumbents and examine *individual* users of the *new and, at least, one incumbent device for the same type of use.* Second, the static model restricts use of the device to a single situation (i.e., home), but we examine use of the new device *across multiple situations*. The model in Fig. 1 comprises three key components: (1) cross-situational use patterns within use-diffusion, (2) determinants of cross-situational use, and (3) outcomes of cross-situational use. In the following sections, we first address the cross-situational use patterns as the central component of the model, and we then discuss the determinants and outcomes accordingly.

A. Cross-situational use patterns within use-diffusion

In the central section of Figure 1, we identify different cross-situational use patterns of the new device in relation to incumbent device(s). We conceptualize cross-situational uses of the new device in two dimensions: depth of complementarity and breadth of substitution. *Depth of complementarity* is the extent to which the focal device performs the same tasks for a similar amount of time as do incumbents irrespective of the situations of use, for example, performing the same learning tasks a similar amount of time with the tablet whilst in-transit as does a laptop during a seminar, and performing these tasks on each device for the same amount of time at home. In contrast to symmetric complementarity, in which dependency relationship is essential (e.g., Internet and PC devices), complementarity-in-use is asymmetric and thus emphasizes a non-essential dependency relationship between multiple PC devices. *Breadth of substitution* refers to the number of times the new device performs tasks in place of incumbent ones across the same use situations – for example, performing the same set of learning tasks a greater number of times on the tablet compared with a laptop at home or a smartphone in-transit.

Combining depth of complementarity and breadth of substitution remains important for cross-situational specialization because, cumulatively, the devices may perform the same tasks for the same amount of time across all situations over a given period. Yet, the new device may perform more/fewer of these tasks in specific situations when other devices are present or absent. Thus, the new device may augment the uses of incumbents [39], [65] by complementing incumbent(s) in different situations for the same tasks or as a substitute for incumbent(s) in the same situation but for different tasks. Thus, we treat the two dimensions as distinct and will now consider their interaction. We derive four sub-patterns of cross-situational use (see Fig. 1) in both specialized and non-specialized use: *extensiveness, congruence, divergence,* and *exclusiveness*.

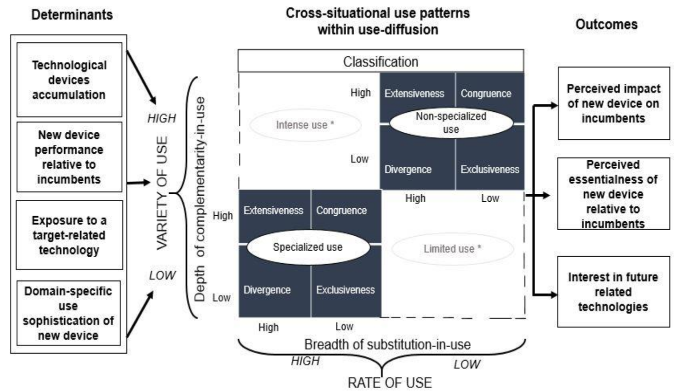

Fig. 1. Cross-situational specialization model[2]

In *extensiveness,* the new device has significant degrees of both depth of complementarity (performs the same tasks a similar number of times as incumbents in different situations) and breadth of substitution (performs the same tasks a greater number of times in place of incumbents in the same situation). For example, although a user might take a similar amount of time to perform email tasks on a desktop in the office as they do on a tablet while in-transit, the user spends a greater amount of time performing these tasks on the tablet compared to a laptop at home. Next, *congruence* explains how the new device tends toward complementarity and performs the same and different tasks a similar number of times as an incumbent in different and same situations respectively. For example, while in-transit, a user might take a similar amount of time to perform email tasks on a tablet as they do on a desktop in the office; but, while at home, they spend a similar amount of time performing different tasks with the tablet (e.g., reading) and a laptop (e.g., typing) than on email tasks.

Divergence refers to a circumstance in which the new device's use tends toward substitution and more frequently fulfills tasks in place of existing devices. For example, although a user reads, downloads documents, and checks emails at home, in-transit, and in the office with a tablet, a laptop, and a desktop, the user might spend a greater amount of time performing these tasks with the tablet compared with a laptop at home or on a desktop in the office. Finally, *exclusiveness* describes a circumstance in which the new device has a low level of both depth of complementarity and breadth of substitution compared with incumbents. For example, despite the minimal amount of time the user spends checking emails on a desktop, a laptop, and a tablet across situations, the user might spend a similar or less amount of time checking emails on the tablet compared to the other devices at home, in-transit, or in the office.

These four patterns apply to *specialized use* in terms of how the new and incumbent devices perform the same tasks *between situations*, and to *non-specialized use* according to how the new and incumbent devices perform such tasks *within situations*. These sub-patterns also distinguish the four conditions either in specialized or non-specialized use based on user characteristics. At a specific point in time, a device's use is associated with only

[2] Intense and limited uses fall outside the scope of this study because they refer to the extent of intensification/limitation of different types of uses across multiple devices based on attributes whereas our model examines the degree of specialization of a new device compared to existing ones for uses across situations.

one sub-pattern for either specialized or non-specialized use. However, this sub-pattern may change due to user learning, new benefits sought, or situational dynamics [31], [55].

B. Determinants of cross-situational uses

The left-hand side of Figure 1 identifies four factors that may affect these cross-situational use patterns as described above: (1) technological device accumulation, (2) performance of new device relative to existing devices, (3) exposure of devices to a target-related technology, and (4) domain-specific sophistication of the new device. These factors have been identified based on the use and continuance adoption of newer generation technologies. Although situational factors, such as the availability of an electrical outlet or battery power, may affect cross-situational use, our model emphasizes the diffusion of a new device in relation to incumbents rather than to how such situational factors affect the choice of devices.

From a new device point of view, related functions but variant features may facilitate the adoption of multiple devices [76], [77] whose performance in-use may arise from the tasks and situations in question [28]. Further, the level of exposure of the devices to an essential complementary technology (e.g., the Internet) may affect the use of the new and existing devices as imperfect substitutes [36]. Finally, domain-specific use sophistication may arise for the devices as a result of the differing levels of performance of the same tasks in different situations [28]. We develop four hypotheses related to these factors with respect to both specialized use (performing the same tasks on devices between situations) and non-specialized use (the degree of task performance on devices within situations).

1) Technological devices accumulation

The first determinant in Figure 1 is the accumulation of technological devices, which refers to the number of devices with related functions but variant features typical of the new device. Shih and Venkatesh [62] demonstrated that accumulated technology experience affects the rate and variety of uses of PCs. Technology experience develops from prior exposure, possession, or use of existing technological devices, which reduces performance uncertainty about related new devices [26], [76] and enhances their adoption in addition to incumbent devices, particularly if the new device's function is cued as different from the incumbent ones [77]. This may lead to a functional overlap between new and incumbent devices.

In specialized use, complementarity entails the same tasks performed with multiple devices, irrespective of the situation, and substitution refers to the degree of performance of these tasks with multiple devices in the same situations. Accordingly, the new and incumbent devices may become complements in specialized use by default, simply because they are imperfect substitutes [36]. In this case, the new device may perform common tasks with all incumbent devices across situations. Hence, the new device's performance of tasks may increase with the increasing number of incumbent devices that the user owns or has access to.

However, non-specialized use entails the degree of performance of tasks on multiple devices within situations after ascertaining the performance of those same tasks on these devices between situations in specialized use. Thus, complementarity and substitution, respectively, explain the similar and different degrees of performance of these tasks by the new and incumbent devices within situations. Although the new device may perform the same tasks as incumbent devices across situations in specialized use, it may be employed more than incumbents whilst in non-specialized use. This pattern occurs because, although the user has formed a habit of performing these tasks with the incumbent devices and continues to maintain this habit, the new device can enhance the performance of these tasks, compared to the incumbent devices, due to its enhanced functionality [77]. Thus, we hypothesize as follows:

H1: *The greater the number of incumbent devices related to the new device, (a) the higher the depth of complementarity in specialized use, but (b) the higher the breadth of substitution in non-specialized use for the new device.*

2) Performance of a new device relative to incumbent devices

The second determinant in Fig. 1 reflects the extent to which a new device facilitates a greater number of tasks than existing ones across situations. Research on bundling of technology components for, and by, users [2], [25] suggests that users may employ multiple devices to perform the same tasks depending on the technological performance of the devices in simplifying the tasks or increasing the number of tasks to be performed across situations [28], [29]. Because specialized use explains the use of multiple devices between situations, the greater performance of a new device relative to incumbents may lead to its facilitation of tasks in more situations. This outcome may arise because the new device (tablet PC) includes an enhanced level of certain features such as portability. However, in non-specialized use, the new device may perform tasks to an equal or greater extent, compared with existing devices, in the same situations because of its enhanced or additional functions. Thus, we hypothesize that:

H2: *The greater the performance of the new device relative to incumbents, (a) the higher the depth of complementarity, but the lower the breath of substitution in specialized use, and (b) the higher the depth of complementarity and breadth of substitution in non-specialized use for the new device.*

3) Exposure of a device's use to a target-related technology

This third determinant in Figure 1 involves exposure to a target-related technology, such as the Internet, as a symmetric complement whose use essentially depends on a class of products such as PC devices [36]. Shih and Venkatesh [62] find that users' exposure to target-related complementary technologies to the PC (e.g., fax machines, videogame consoles), enhances the use-diffusion of the PC and affects the uses of the complementary technologies. Research also shows that the adoption of PCs is intricately linked to diffusion of the Internet [18]. Thus, the level of exposure of the new device's use to the Internet may constrain or enhance its performance of tasks between or within situations compared to other devices. Considering that the diffusion of PCs with the Internet involves the cost of infrastructure installation, particularly for first-generation devices [18], Internet use on incumbent devices may be limited to specific situations, such as home use. Additionally, the evolution of IT from analog to digital may constrain or enhance Internet access across multiple devices depending on its cost to users [36]. Accordingly, in specialized use, greater exposure of the new device's use to a target-related technology (i.e., the Internet) may lead to a reduced likelihood of employing other devices to perform the same tasks as the new device in situations where the Internet is easily accessible across devices. However, in non-specialized use, greater exposure of the new device's use to the Internet should lead to a similar or greater degree of performance of tasks by the new device compared with incumbents. This is because, in static situations such as the home or the office, access to Wi-Fi on multiple devices may come at a fixed cost, and the access may be unlimited over a period (e.g., a month). Additionally, the enhanced functions of the new device may enable greater performance of some tasks compared with existing devices. Thus, we hypothesize that:

H3: *The greater the exposure of the new device to a target-related technology, (a) the lower the likelihood of complementarity or substitution in specialized use, but (b) the higher the depth of complementarity and breadth of substitution in non-specialized use for the new device.*

4) Domain-specific use sophistication of a device

The fourth and final determinant in Figure 1 involves the inherent characteristics of technology-related products that define their sophistication. Such sophistication may arise when customer- or user-migration paths for an evolving technology are affected by successive generations positioned at different levels [52] with both similar and different functionalities [30]. With the increasing exposure of computers to the cloud [8], domain-specific use sophistication may arise from the differing levels of exposure of multiple devices to same types of use with varying tasks across situations [60]. For example, as a result of differing levels of sophistication, a user may scan a hardcopy document with a tablet and save it in the cloud, engage a laptop to convert this document from one file format to another (e.g., PDF, JPEG), and access the document frequently from the cloud with their smartphone for reading.

Thus, in specialized use, greater domain-specific use sophistication of the new device may lead to the performance of the same tasks by the new and incumbent devices but more so in the same than in different situations. This behavior arises because although the devices are embedded with similar functions, the new device comes with enhanced features (e.g., platforms for apps) that enable the performance of more of the tasks usually performed by incumbent devices as an imperfect substitute [65]. However, in non-specialized use, greater domain-specific use sophistication of the new device may lead to a similar or greater degree of performance of tasks by the new device in the same situations compared with incumbents. Essentially, the newness and enhanced features of the device (at the time) may influence the use of the new device more frequently, compared with incumbents, within those situations. Thus, we hypothesize as follows:

H4: *The greater the domain-specific use sophistication of new the device, (a) the lower the depth of complementarity but the higher the breadth of substitution in specialized use, and (b) the higher the breadth of substitution in non-specialized use for the new device.*

C. Outcomes of cross-situational uses within use-diffusion

The right-hand side of Fig. 1 shows the outcomes that may result from cross-situational use patterns, including (1) perceived impact of the new technological device on incumbents, (2) perceived essentialness of the new device, and 3) interest in future-related technologies. These outcomes are derived from studies of the multiple adoption of substitutable and complementary technological devices [26], [36], user perception on the performance of the new device in relation to incumbents in-use [62], [76], [77] and the bundling and distinction of functional features of new generation devices for users [2], [28]. We now discuss these outlines in more detail.

1) Perceived impact of the new technological device on incumbent devices

When users become familiar with existing technological devices, they continue to adopt newer generation devices to guarantee or enhance the use of the incumbent devices. Shih and Venkatesh [62] found that use-diffusion leads to interest in future-related technologies. As such, users may adopt new technological devices based on prior experience, possession, or use of the incumbent devices [76], [77]. In specialized use, the exclusiveness sub-pattern should result in the highest consideration of the new device as enhancing the use of incumbent devices compared with all the other sub-patterns. This is because, when multiple devices serve the same use with similar attributes, users judge their performance similarly in terms of attribute performance levels [76]. However, differences in attributes can also differentiate between the new and incumbent devices in terms of use [77]. Thus, the exclusiveness sub-pattern involving both lower complementarity and substitution may reduce the uncertainty costs of integrating the new device with incumbents for the same use and help establish a point of difference for the new device.

However, in non-specialized use, the divergence sub-pattern should result in the highest consideration of the new device as enhancing the use of incumbent devices compared with all the other sub-patterns. Although the new and existing devices perform the same tasks, situations in which the new device increasingly performs these tasks better than the existing devices will establish a *niche* performance for the new device. Such a niche performance of the new device characterizes the divergence sub-pattern in which the device has a high breadth of substitution and a lower depth of complementarity in-use with existing devices. Therefore, we hypothesize as follows:

H5: *The perception of the new device's enhancement of uses of incumbent devices will be (a) highest for the exclusiveness sub-pattern compared with all other sub-patterns in specialized use, and (b) highest for the divergence sub-pattern compared with all other sub-patterns in non-specialized use.*

2) Perceived essentialness of the new technological device

Prior research has discussed the effect of a successful use of a technology on satisfaction [4], [35] as well as its essentialness to users [62]. Existing technological devices performing similar functions for users also may affect user perception of a new technology's essentialness. For instance, Han, Chung and Sohn [28] found that, depending on technological performance, users may draw on multiple devices for the same tasks but in different situations. By implication, user perception of the new device's essentialness may arise from its level of integration with incumbent devices to perform tasks across situations.

In specialized use, the exclusiveness sub-pattern should result in the highest perception of the new device's essentialness. Users can derive the benefits of lower search costs, lower risk of trial, and lower costs of uncertainty about use from the integration of devices [76], [77]. This perceived essentialness of the new device arises from the performance of some core uses across multiple devices regardless of differences in attributes or features. In contrast, the divergence sub-pattern should result in the highest perception of the new device's essentialness in non-specialized use. Despite the integration of the devices for the same tasks, users may apply the new device more in situations in which incumbent devices perform tasks to only a minimal extent [28]. Therefore, we hypothesize that:

***H6:** The perceived essentialness of the new device as part of a set of integrated devices will be (a) highest for the exclusiveness sub-pattern compared with all other sub-patterns in specialized use, and (b) highest for the divergence sub-pattern compared with all other sub-patterns in non-specialized use.*

3) Interest in new (future) technologies

The static use-diffusion model shows that use of a new technology leads to an interest in future-related technologies. This is because, when a technology becomes a part of users' daily activities, users become more satisfied with the technology, and their level of resistance to adopting an alternative increases [35]. Moreover, the diffusion of a technology into households increases the perception of its essentialness in the home, and its impact on daily life, meaning users may become interested in acquiring future-related technologies [62]. Because the level of interest in acquiring a future technology depends on the extent of users' integration of existing technologies into their daily activities, users may be interested in a technology with a distinctive function that offers a superior performance of specific tasks or a bundle of functions that converge around the user's goal [28], [29]. The difference between technologies with distinct and bundled functions remains important for innovators because the bundling of functions of new technologies in the upstream may be wasted if the user is interested in a distinct function in that bundle to facilitate their own bundling of different technologies in the downstream [2], [25].

Shih and Venkatesh [62] found that non-specialized use leads to a higher interest in future-related technologies compared with a specialized use because of the time and effort required to develop expertise in applying existing technology to routine tasks in specialized use. User preferences between technologically distinct and bundled devices are based on the performance of their attributes [28]. Thus, interest in future technologies may differ between the uses of these types of devices. We predict that the exclusiveness sub-pattern will result in the highest interest in future-related *technologically distinct devices* compared with all other sub-patterns in specialized use. This is because users may have invested time and effort in learning the uses of the devices for routine tasks [62] and, as such, may require enhanced, rather than additional, functions in a new device [39]. However, we expect no significant differences between the sub-patterns in the non-specialized use in terms of interest in future-related *technologically distinct devices.* Because non-specialized use involves differences in the use of devices based on attributes, users may prefer more variety to the simplicity of attributes [29]. Thus, we hypothesize that:

***H7a:** Within specialized use, the exclusiveness sub-pattern will result in the highest interest in a future-related technologically distinct device compared with all other sub-patterns.*

***H7b:** Within non-specialized use, there will be no significant differences between the sub-patterns for interest in future-related technologically distinct devices.*

For a *technologically bundled device*, although we expect the exclusiveness sub-pattern in specialized use to result in the highest interest among users, this interest should not be significantly different from the congruence sub-pattern. Because a technologically bundled device incorporates the functions of other devices, it is likely to share uses with other existing devices [28], [29]. However, in non-specialized use, the divergence sub-pattern will result in the highest interest in the *technologically bundled device* compared with all other sub-patterns. This is because, besides the general emphasis on the different uses of multiple devices in non-specialized use, the divergence sub-pattern emphasizes substitution of one device for multiple tasks. Therefore, a technologically bundled device, which incorporates the functions of multiple devices, should perform an increasing number of tasks in place of other devices for the divergence sub-pattern. Nonetheless, considering that a technologically bundled device shares uses with other devices [28], we expect no significant differences between the interest shown in the divergence sub-pattern and those in the extensiveness sub-pattern within non-specialized use. This is because the substitution of a new technologically bundled device for incumbents may also lead to a complementarity with such incumbent devices. Therefore, we hypothesize as follows:

***H8a:** Within specialized use, although the exclusiveness sub-pattern will result in the highest interest in a future-related technologically bundled device, this will not be significantly different from that of the congruence sub-pattern.*

***H8b:** Within non-specialized use, although the divergence sub-pattern will result in the highest interest in a future-related technologically bundled device, this will not be significantly different from that of the extensiveness sub-pattern.*

IV. METHODS

A. Sample

To examine the diffusion of the tablet PC in-use alongside incumbent PC device(s), we select the learning and educational use context. Because we examine the same type of use across multiple devices, we seek to generalize the validity of the sample to one-to-one relationships between, for instance, a university and its individual actors, such as students or employees. Shih and Venkatesh [62] identified various types of PC use including learning, working, entertainment, and financial and information management, among other uses. However, we deem learning and education use to be the most appropriate to achieve a reasonable level of parsimony in understanding the relationship between traditional and reversed IT adoption. This is because learning and education use provides a context to examine the structured and unstructured use of PC devices across a variety of situations [60]. This is unlike working or entertainment uses, which may be skewed towards structured and unstructured tasks respectively. Accordingly, cross-sectional survey data were collected from respondents studying at Australian universities who own and apply tablet PCs for learning and educational use. A substantial proportion of individuals studying at university are highly knowledgeable about technology, and the current generation of students is driving the increasing adoption and diffusion of mobile computing devices in higher education. A survey in Canadian and U.S. universities showed that more than 67% of students consider mobile devices important to their academic outcomes [15]. We focus on a tablet PC, which at the time of data collection was a relatively newer addition. Tablets offer functions similar to, yet also different from, those of other PC devices, suggesting a functional design as an imperfect substitute. Arguably, nowadays, mobiles have become more important, and the question is whether a tablet's use has levelled off. However, this study emphasizes how the interaction between the tablet and other PC devices as part of a system and as units explains the sustainability of new generation devices.

The population of potential respondents covered all of Australia. However, because the questionnaire sought to maximize the exchanges occurring around the same type of use for new and incumbent devices across situations, the sample selection was purposive [32]. Qualtrics, a well-regarded market research company, was selected to sample and administer the questionnaire and obtain a balanced and representative sample from the target population. An initial questionnaire was pretested with 30 undergraduate, postgraduate coursework, and postgraduate research students from a large Australian university, with students drawn from different faculties and departments. Their feedback was incorporated into the final version of the questionnaire. Potential respondents were first asked if they owned a tablet PC, and non-owners were excluded. The remaining candidates were then asked if they employed the tablet for learning and educational uses. If so, they completed the questionnaire; otherwise, they were screened out.

Information on use of other device(s) at least once a week, use of a tablet PC, and period of ownership of device(s) was also captured to ensure that the user's adoption of the tablet computer followed on from their experience with at least one existing type of PC device. A total of 363 respondents attempted the survey, with 315 (86%) respondents, consisting of 38% men and 62% women, satisfactorily completing the entire survey. All 315 respondents indicated that, in 2014, they had owned and frequently used a laptop in the previous five years. Thus, we concluded that the tablet PC, which was widely adopted after the launch of the iPad in 2010, follows the laptop as a new generation device.

TABLE I
TASKS AND SITUATIONS FOR EMPIRICAL MEASURES

Tasks	Situations of use
-Accessing school's online portal	-At home
-Accessing/writing school-related emails	-In the office
-Reading a short note/document	-At a lecture/seminar/group discussion
-Reading a comprehensive document/e-book/article	-In-transit (in a car, in a train, in a flight, walking)
-Writing/typing a short note/jotting down points	-At a destination other than those listed (e.g., open place like a park)
-Writing/typing a comprehensive document/assignment	
-Audio/video recording a lecture/presentation/seminar	
-Watching/listening to lecture/presentation/seminar	
-Downloading articles and educational materials	
-Printing articles and educational materials	
-Storage/saving articles/educational materials	
-Designing symbols/diagrams/tables	
-Data analysis/calculation of data	
-Delivering a lecture/presentation/seminar	
-Accessing any other Internet-related educational material not listed above	

B. Measures

1) Dependent variable: Complementarity and substitution in specialized use

Specialized use involves a high rate but a low variety of use. Thus, the measures of complementarity and substitution involve the occurrence of tasks on new and incumbent devices across situations. Substitution involves the same tasks on multiple devices in the same situations [67], [68], whereas complementarity involves the occurrence of the same tasks on multiple devices across different situations [58], [65]. We measure complementarity and substitution with 15 learning and educational tasks observed across 5 situations, as shown in Table I, displayed in a matrix of 75 cells. We identified these as appropriate tasks and situations to consider after an in-depth two-hour focus group discussion with 10 research students.

For complementarity, we observe counts of categorical responses (1 = "yes," 0 = "no"). The measures indicate cells for which respondents indicated employing a tablet PC (1 = "yes") and other devices (1 = "yes") for tasks in the same situations; for which they employed the tablet for a task in one situation (1 = "yes") but employed other devices for the same task in a different situation; and for which they employed the tablet for tasks in one situation (1 = "yes") but both the tablet and other devices for the same tasks in another situation. Adding the three counts and dividing by the number of cells (maximum of 75) to which each user responded, relative to both the tablet and other devices, provides the measure of complementarity-in-use.

For substitution, we count responses to cells in which respondents indicated employing a tablet PC (1 = "yes") as well as other devices (1 = "yes") for tasks in the same situations. We again sum the counted cells and divide by the maximum number of cells (75) to which the user responded for both the tablet and other devices. Using mean splits, we dichotomize complementarity and substitution, denoting them as having high/low depth and breadth, respectively, because our measures of both variables are based on an index. The dichotomization makes the measures adaptable to arithmetic and algebraic treatments [47], [61]. Together, complementarity and substitution form a 2 × 2 matrix of sub-patterns within specialized use (see Fig. 1). See Tables II and III below for the distribution of respondents.

2) Dependent variable: Complementarity and substitution in non-specialized use

Non-specialized use involves a high variety but low rate of use, capturing the degree of application of devices to tasks within situations. Within situations, substitution entails performing the same tasks a different number of times across multiple devices; complementarity pertains to performing the same tasks the same number of times across multiple devices [58], [65]. We consider 15 learning and educational tasks and 5 situations (Table I). For complementarity, we count responses to the cells for which the respondent indicated the same degree of engagement of the tablet as other devices for use (1 = "least engaged," and 4 = "most engaged"). Then, we sum the values of the degree of engagement of the tablet with the same value as those for other devices. The total degree of engagement of the tablet is divided by the total degree of engagement of all devices (tablet inclusive) in all cells (maximum of 75), irrespective of the degree of engagement of any of the devices by the user.

For substitution, we count responses to the cells representing the same situations in which both the tablet and other devices indicate an engagement (1 = "least engaged," and 4 = "most engaged"). The count of cells includes those in which the tablet indicates an engagement, which may be greater than, equal to, or less than that on other devices. We sum the values on the tablet and on other devices for these tasks in the same situations and then calculate the ratio of the degree of engagement of the tablet for those tasks in such situations. We sum the ratios for the tablet to the tasks in each situation and divide this sum by the number of cells in which the tablet and other devices show an engagement (maximum of 75). We dichotomize complementarity and substitution into high/low depth and breadth, respectively, with a mean split, to adapt the measures to arithmetic treatments. Thus, complementarity and substitution form a 2 × 2 matrix (Fig. 1) of sub-patterns in non-specialized use.

TABLE II
MEASURES FOR COMPLEMENTARITY AND SUBSTITUTION IN-USE

	Mean		**Median**		**Standard deviation**	
	Specialized use	Non-Specialized use	Specialized use	Non-Specialized use	Specialized use	Non-Specialized use
Complementarity-in-use	0.77	0.48	0.83	0.49	0.23	0.09
Substitution-in-use	0.66	0.30	0.68	0.30	0.26	0.13

TABLE III
CLASSIFICATION OF RESPONDENTS INTO CROSS-SITUATIONAL USE PATTERNS

Cross-situational patterns	Complementarity-in-use	Substitution-in-use	Percentage of sample	
			Specialized use %	Non-Specialized use %
Extensiveness	High	High	42.4	35.2
Congruence	High	Low	12.4	18.4
Divergence	Low	High	11.2	14.6
Exclusiveness	Low	Low	34.0	31.8

3) Independent variable: Determinants of cross-situational use

We operationalize *technological devices accumulation* as the number of different types of PC devices with at least one functional feature of the tablet (i.e., the desktop, the laptop, the e-reader, and the smartphone). We measure *new technology performance relative to incumbents* as the number of tasks performed with greater frequency of occurrence on the tablet, multiplied by the number of situations in which the tablet can perform a greater number of tasks compared with other devices, and this is divided by 75 cells. *Exposure to a target-related technology* was measured by the ratio of hours spent on the Internet on the tablet PC to the hours spent on the Internet across all devices (tablet inclusive) per week. *Domain-specific use sophistication of device* reflects the average degree of engagement of the tablet and other devices for 15 tasks across 5 situations. We note that the measurement of these independent variables with proxies generally poses some limitations. However, in the context of PC technologies, such proxy measures are considered acceptable for operationalizing user behaviors [19], [62].

Finally, we include user expertise and the acquisition capability of devices as control variables, to test if the main hypotheses hold in the presence of these characteristics. We include user expertise because Anderson and Ortinau [4] revealed that with PC devices, use often precedes adoption. Similarly, we include acquisition capability because Golder and Tellis [27] found that users' ability to afford a new technology enhances its diffusion for such users. Table IV summarizes the measures for the determinants of cross-situational uses.

4) Outcomes of cross-situational uses within use-diffusion

We adapted the measures of perceived enhancement of the uses of existing devices by the new device and the perceived essentialness of the new device from the 5-point Likert scales developed by Shih and Venkatesh [62]. Additionally, drawing on Han et al. [28] and Shih and Venkatesh [62], four fictional devices were each presented to respondents as technologically distinct and bundled devices relating to education and learning experience delivery to measure their level of interest in these devices (1 = least interested, and 4 = most interested). These fictitious devices were developed from a focus group discussion that formed part of the questionnaire development process. We examine only variations in the outcomes as a result of the classification of respondents into sub-patterns in specialized and non-specialized use patterns. Thus, we take the mean of

TABLE IV
SUMMARY OF DETERMINANTS OF CROSS-SITUATIONAL USES

Variable Name and Description	Measure	Mean	Standard Deviation
Technological device accumulation	The number of different types of PC devices with, at least, one functional feature of the tablet (i.e., the desktop, the laptop, the e-reader, and the smartphone) owned by the user, indexed against the maximum number of devices under consideration (4)	2.90	0.81
New device performance relative to incumbents	Number of tasks with greater frequency of occurrence on the tablet compared with other devices, multiplied by the number of situations in which the tablet has greater number of tasks compared with other devices, divided by 75 cells	0.11	0.18
User exposure to a target-related technology	The ratio of number of hours spent on the Internet on the tablet to the number of hours spent on the Internet across all devices (tablet inclusive) per week	0.22	0.26
Domain-specific use sophistication of devices	The average level (1 = minimum, 4 = maximum) of application of the tablet and other devices to 15 tasks across 5 situations	1.53	0.80
User expertise	A five-item scale adapted from Price and Ridgway (1983), with α = 0.840, AVE = 0.6178	2.19	0.72
Acquisition capability of technologies	A one-item scale to measure the ability of respondents to acquire or purchase the technologies in the category under study (1 = minimum, 5 = maximum)	4.07	0.90

each outcome variable for the analysis and perform a reliability check on the first two outcomes measuring user perceptions to assess the internal consistency of the items measuring those variables. Table V shows that each of the variables measuring user perceptions has a Cronbach's alpha value greater than 0.70, so they are reliable for this analysis [51].

TABLE V

ASSESSMENT OF MEASUREMENT SCALES FOR OUTCOME VARIABLES

Variable	Mean	Standard Deviation	Median	Cronbach's Alpha (α)
Perceived impact of new device on incumbents	2.04	0.77	2.00	0.884
Perceived essentialness of the new device in relation to incumbents	2.24	0.86	2.20	0.903
Interest in future-related technologically distinct device	2.03	0.73	2.00	
Interest in future-related technologically bundled device	1.90	0.77	1.75	

V. ANALYSIS AND RESULTS

Fig. 1 (model) contains three major components, namely, cross-situational use patterns, determinants, and outcomes, along with more granular subcomponents. In cross-situational use, we examine cross-situational patterns in specialized and non-specialized use. While these patterns in specialized use explain the occurrence of the same tasks on multiple devices between situations, those in non-specialized use explain the degree of task occurrence on the devices within situations.

In specialized use, the four patterns are the levels of a categorical variable, which explains the likelihood of every user experiencing one of those patterns as a result of the determinant variables. However, for users who may be engaging with the new and existing devices across the same situations, the four patterns in non-specialized use explain the likelihood of a user experiencing one of those patterns on top of their experience in specialized use. Given the categorical nature of the dependent variable(s), i.e., specialized and non-specialized use, and the four levels of the dependent variables (four patterns), we adopt a multinomial logistic regression (MNL) analysis to examine the relationship between the determinants and the occurrence of cross-situational use patterns. MNL regression analysis is the most appropriate linear regression to adopt when the analysis involves a categorical dependent variable with more than two levels because it enables the estimation of the likelihood of occurrence of any of the levels by utilizing one of them as a control group [10]. In this, it differs from multiple discriminant analysis, which focuses on maximizing, instead of estimating, the occurrence likelihood of the differences between the groups.

However, for the outcomes of cross-situational use patterns, although we examine the variation in the four sub-patterns for both specialized and non-specialized use, the ultimate purpose for analyzing the outcomes is to examine user perception of the new device's co-existence with existing devices across different situations compared with the extent of such co-existence within the same situations. Ultimately, we compare the sub-pattern with the highest mean in specialized use to that in non-specialized use to determine the consistency (or otherwise) of user perception of the co-existence relationship in specialized and non-specialized use. Thus, we employ analysis of variance (ANOVA) with multiple post hoc contrasts to estimate the hypothesized relationships between cross-situational use patterns and the outcomes.

A. Multinomial logistic regression (MNL) analysis

MNL regression analysis estimates the number of categories (k) of a dependent variable according to k-1 logit equations [10]. MNL utilizes one category as a control category for comparing the parameter estimates of the other categories [62]. Thus, we conduct an MNL regression analysis of the four sub-patterns, using the exclusiveness sub-pattern as a control category in both specialized and non-specialized use. We interpret the results based on parameter estimates and standard errors in Table VI. The determinants explain the sub-patterns in specialized use ($R^2 = 0.543$) better than in non-specialized use ($R^2 = 0.232$).

The results show that the accumulation of technological devices has no significant relationship with the sub-patterns in

TABLE VI

RESULTS OF MNL REGRESSION ANALYSIS

	Specialized pattern of use-diffusion						Non-specialized pattern of use-diffusion					
	Extensiveness	S. E.	Congruence	S. E.	Divergence	S. E.	Extensiveness	S. E.	Congruence	S. E.	Divergence	S. E.
Intercept	-4.371***	1.222	-1.305	1.948	-3.378	2.039	-3.752***	1.192	-3.290**	1.352	-5.451***	1.458
Technological device accumulation	1.262	0. 813	-0.012	1.144	2.728	1.682	0.472	0.797	1.020	0.911	1.249	0.984
New device performance relative to incumbents	1.357	1.185	7.451***	1.278	-16.916	9.281	2.973***	0.962	0.399	1.173	1.379	1.267
Exposure to a target-related technology (Internet)	1.737	0.738	0.388	1.185	0.723	1.295	3.609***	0.763	2.820***	0.829	1.090	0.907
Domain-specific use sophistication of device	2.122***	0.274	0.095	0.438	0.909**	0.456	0.726***	0.219	-0.241	0.247	0.649**	0.262
User expertise	-0.040	0.146	-0.373	0.270	0.056	0.246	0.190	0.155	0.144	0.171	0.546***	0.175
Acquisition capability of technologies	-0.005	0.182	-0.163	0.286	-0.396	0.326	0.007	0.175	0.195	0.211	0.208	0.217
-2 LL	475.861						757.933					
Model χ^2	203.895***						76.392***					
Pearson χ^2	763.974						1028.692					
Pseudo – R^2	0.543						0.232					

** $p < 0.05$, *** $p < 0.01$. **Notes:** The exclusiveness sub-pattern is the control category in specialized use and in non-specialized use.

specialized ($\beta = 1.262$, n. s.) or non-specialized ($\beta = 1.249$, n. s.) use. This finding does not support H1a and H1b. In support of H2a and H2b, though, the new device's performance relative to that of incumbent devices relates positively to the congruence sub-pattern in specialized use ($\beta = 7.451$, $p < .01$) and to the extensiveness sub-pattern in non-specialized use ($\beta = 2.973$, $p < .01$). Consistent with H3a and H3b, exposure to a target-related technology has no significant relationship with the sub-patterns in specialized use, but it relates positively to the extensiveness ($\beta = 3.609$, $p < .01$) and congruence ($\beta = 2.820$, $p < .01$) sub-patterns in non-specialized use. The domain-specific use sophistication of the new device relates positively to the divergence sub-pattern in specialized use ($\beta = 0.909$, $p < .05$) and the extensiveness sub-pattern in non-specialized use ($\beta = 0.726$, $p < .01$), as we predicted in H4a and H4b.

Among the control variables included to test if the main hypotheses hold in the presence of various user characteristics, we find that user expertise relates positively to the divergence sub-pattern in non-specialized use ($\beta = 0.546$, $p < .01$). Another control, acquisition capability, has no significant relationship with any of the sub-patterns in specialized or non-specialized use.

B. CSS outcomes: Analysis of variance (ANOVA) with multiple post hoc comparisons

An ANOVA with multiple comparisons (Tables VII and VIII) reveals comparable outcomes across the sub-patterns in specialized and non-specialized use. Specifically, users who fell into the exclusiveness sub-pattern in specialized use rated the new device highest in terms of its enhancement of the uses of incumbent devices compared with the congruence, extensiveness, and divergence sub-patterns, respectively (2.340 versus 1.985, 1.877, 1.786, $p < 0.01$). In contrast, in non-specialized use, respondents in the divergence sub-pattern rated the new device highest for its enhancement of uses of incumbent ones compared with the exclusiveness, congruence, and extensiveness sub-patterns, respectively (2.344 versus 2.180, 2.076, 1.780, $p < 0.01$). These findings support H5a and H5b. Additionally, and though not hypothesized, the rating of the new device's enhancement of the uses of incumbent devices remains higher for the divergence sub-pattern in non-specialized use (H5b) than for the exclusiveness sub-pattern in specialized use (H5a) (2.344 versus 2.340, $p < 0.01$).

Regarding the new device's essentialness, respondents in the exclusiveness sub-pattern rated the new device highest, above the congruence, extensiveness, and divergence sub-patterns, in specialized use (2.652 versus 2.108, 2.017, 1.971, $p < 0.01$), whereas the divergence sub-pattern produced the highest ratings of the new device above the exclusiveness, congruence, and extensiveness sub-patterns in non-specialized use (2.630 versus 2.464, 2.210, 1.897, $p < 0.01$). These findings are consistent with our predictions in H6a and H6b. Additionally, and though not hypothesized, the rating of the new device's essentialness as part of integrated devices remains higher for the exclusiveness sub-pattern in specialized use (H6a) compared with the divergence sub-pattern in non-specialized use (H6b) (2.652 vs. 2.630, $p < 0.01$).

The results also show that users who fell into the exclusiveness sub-pattern in specialized use expressed the highest interest over the congruence, divergence, and extensiveness sub-patterns respectively, in future technologically distinct devices (2.286 versus 2.200, 1.957, 1.808, $p < 0.01$). However, as predicted, there is no significant difference amongst the sub-patterns in non-specialized use for interest in future technologically distinct devices. This finding supports H7a and H7b. Finally, the results show that although the exclusiveness sub-pattern in specialized use leads to the highest interest in future technologically bundled devices, this is not significantly different from that of the congruence sub-pattern. However, the exclusiveness and congruence sub-patterns remain significantly different from the divergence and extensiveness sub-patterns in specialized use (2.222 & 1.936 versus 1.692 & 1.661, $p < 0.01$). Surprisingly, no significant differences were found among the sub-patterns in non-specialized use for interest in future-related technologically bundled devices. Thus, while H8a is supported, H8b is not.

TABLE VII
ANOVA WITH MULTIPLE COMPARISON T-TESTS FOR THE OUTCOMES OF CROSS-SITUATIONAL USE PATTERNS

	Specialized pattern of use-diffusion					**Non-specialized pattern of use-diffusion**				
	F	Extensiveness	Congruence	Divergence	Exclusiveness	F	Extensiveness	Congruence	Divergence	Exclusiveness
Perceived impact of new device on incumbents	9.003***	1.877^c	1.985^b	1.786^c	2.340^a	8.344***	1.780^c	2.076^c	2.344^a	2.180^b
Perceived essentialness of the new device	14.051***	2.017^b	2.108^b	1.971^b	2.652^a	12.629***	1.897^c	2.210^c	2.630^a	2.464^b
Interest in future technologically distinct device	11.015***	1.808^c	2.200^b	1.957^b	2.286^a	2.020	1.937	1.924	2.144	2.128
Interest in future technologically bundled device	11.447***	1.692^b	1.936^a	1.661^b	2.222^a	1.939	1.775	1.892	1.940	2.028

***$p < 0.01$.

TABLE VIII
ANOVA COMPARISON OF SUB-PATTERNS IN SPECIALIZED AND NON-SPECIALIZED USE

	Specialized pattern of use-diffusion	Non-specialized pattern of use-diffusion
	Exclusiveness	Divergence
Perceived impact of new device on incumbents	2.340^b	2.344^a
Perceived essentialness of the new device in relation to incumbents	2.652^a	2.630^b

***$p < 0.01$

VI. DISCUSSION

This study examines the CSS of a newer generation device that co-exists with incumbent devices in-use. The findings support this co-existence relationship. In particular, the co-existence is stronger when the new and incumbent devices perform the same tasks in different, compared with same, situations. This finding confirms the underlying interaction between the time (rate and frequency) and versatility (variety of functional and situational applications) elements of technology use-diffusion patterns [62], [64]. However, the finding suggests that the interaction is stronger when versatility involves different functional, compared with situational, uses. Further, although the versatility of devices is a rich construct, a comparison of a given device with competing devices within use situations provides greater clarity.

Contrary to our prediction in H1, the number of incumbent devices similar to the new one has no significant relationship with CSS of use. As a single variable, incumbent device accumulation is significantly related to CSS of use, but the inclusion of other variables attenuates this significant effect in the model. This is an interesting finding because it confirms that, although the features of a new device that are typical of the features of incumbent devices may encourage its adoption [76], explicit comparison between the new and incumbent devices tends to backfire against the new device when its functionality is not atypical of the incumbents [77]. The finding also highlights a fundamental observation by Srivastava, Alpert, and Shocker [67] that the features of products may not equate to their benefits-in-use. The finding underscores the importance of ownership of multiple devices with common features regardless of use; this is because ownership may offer some abstract benefits, such as a guaranteed access to different devices when use occurs. However, the abstract benefits diminish when other factors affect their application in-use. This distinction is critical to the long-term adoption of IT devices and the waste and proliferation of devices.

Consistent with our prediction for H2, the results show that although the new device's performance relative to that of incumbent devices facilitates the application of the new device to more tasks than the incumbents, this outcome occurs more in different than in same situations of use. However, within the same situations, the application of the devices to such tasks occurs similarly or to a greater extent on the new device compared to incumbents. This finding is consistent with the emergent challenges confronting new technologies and the extension opportunities available to incumbent technologies in technology systems [1]. In particular, when successive technology generations are positioned differently for the adopter based on the sophistication of attributes, the relative advantages of both the new and the incumbent technologies [52] may lead to differing levels of substitution between the new and the incumbent technologies. The finding implies that although new technologies might face emergence challenges because of the extension opportunities available to incumbent technologies, the emergence challenge may be limited when the relative advantage of the new technology involves multiple situations of use.

In support of H3, user exposure to a target-related technology (the Internet) has no significant relationship with use of the devices between situations. Rather, within the same situations where the Internet is easily accessible, the application of the devices to the same tasks occurs similarly or to a greater extent on the new device compared to the incumbents. This finding confirms existing research on the diffusion of complementary technologies [18], [36] and suggests that although essential complementary technologies (e.g., Internet) may encourage the adoption of multiple devices, use of the Internet may vary according to its accessibility on devices across situations. In situations of greater accessibility to the Internet, symmetric complementarity of the Internet generates high levels of asymmetric complementarity between multiple devices, as users employ multiple devices to perform the same and different tasks, but the newest amongst the devices enjoys a greater level of use compared to the incumbents.

Consistent with the predictions in H4, domain-specific sophistication of use is significantly related to the application of the new device to the same tasks as the incumbents more across the same, than in different, situations. However, within the same situations, the new device's application to these tasks occurs to a greater extent compared to the incumbents. This finding is consistent with the continuance adoption and use of technologies as a result of the differences in the basic and innovative functions of devices [9], [30], [66]. However, the finding suggests that although the continuance adoption and use of devices may arise from user behavior towards the innovative functions of incumbent devices, sophistication of use within the device domain leads to maximization of the innovative functions of the newest device at the expense of those of incumbents across and within the same situations of use.

In support of H5, the results show that although users generally perceive the new device to enhance the uses of incumbents, this perception is stronger when users apply the new and incumbent devices to tasks that lie within the same, compared to different, use situations. However, in support of H6, although users generally perceive the new device's essentialness to be significantly dependent on its integration with incumbents for the same tasks, the perception is stronger when users apply the new and incumbent devices more to tasks across different, rather than within the same, situations. These findings confirm the effect of successful technology use-diffusion on user perceptions of the impact of the new device and consideration of its essentialness for daily tasks [62]. The findings suggest that user perception of the impact of a new device may increase significantly when such a device makes a greater number of tasks conveniently accessible in situations where incumbents have limited sophistication for such tasks. Conversely, user perception of the new device's essentialness increases significantly when it makes some core tasks easily accessible in different situations where incumbents are not or cannot be applied.

Finally, in support of H7, the results show that user application of the new device to the same tasks as incumbents across different, and within same, situations leads, respectively, to a) significant and b) no significant user interest in future-related technologically distinct devices. However, in partial support for H8, user application of the new device to the same tasks as incumbents across different, and within same, situations leads, respectively, to a) significant and b) no significant user interest in future-related technologically bundled devices. These findings draw an important linkage between the adopter's processes through use-diffusion [62] and the innovator's processes in technology ecosystems [72] in which the sustainability of technology transitions depends on knowledge of the incumbent technologies [14]. The finding implies that although the use of incumbent PC devices may facilitate continuance adoption, future adoption of technologically distinct (single function) and bundled (multiple functions) devices depends on the situations of their use rather than the features or components of the devices *per se*.

A. Theoretical contributions

Our study contributes to the demand side of technology diffusion research in four key ways by reconciling traditional and reversed IT adoption logics in the context of individual use of personal devices in organizational contexts. First, reversed IT adoption logic, particularly in organizational contexts, emphasizes BYOD mechanisms, which facilitate a complete substitution of organizational devices with personal mobile devices (e.g., [5], [6], [42], [43], [44]. This approach considers IT adoption as a bundle of technologies without any distinction between the devices and the systems embedded in those devices. This study views IT adoption as constitutive of the ownership/replacement of devices [33], the acceptance and use of IT systems embedded in devices [17], [74], and the use-diffusion of the attributes of IT devices and systems [62], [64]. Accordingly, this study shows that reversed IT adoption may not lead to a complete substitution of personal mobile devices for organizational devices. Rather, reversed IT adoption may be partially constrained to the attributes of IT devices and/or systems when newer generation mobile technologies are substituted for incumbent ones in-use but the substitution works only imperfectly.

Second, while research on traditional IT adoption of newer generation devices mostly emphasizes the perfect substitution of incumbent devices with newer generation versions [16], [33], [49], [50]), this study examines the newer generation devices as an imperfect substitute for incumbent ones [26] in-use. Accordingly, this study contributes to the replacement models in technology diffusion by demonstrating that rather than substituting an incumbent device with a new version, users may adopt the new one as an addition to incumbent type(s) of devices when both the new and incumbent devices have distinctive attributes, which are sophisticated for the same type of use in different situations.

Third, research on traditional adoption of IT systems embedded in devices such as TAM [17], [73], UTAUT and UTAUT2 [75], [20], [3], [56], [71] mostly emphasize the perception and expectations of uses of the system, without discriminating between the different applications, which facilitate acceptance and use of the system. This study instead discriminates between the applications of the IT system of PCs to different tasks. By doing so, the study shows that when traditional IT adoption is measured by how perceived and expected uses of IT systems facilitate technology acceptance and use, it is important to discriminate between the applications of the system to specific tasks to better understand the applications that drive technology acceptance and use.

Finally, research on traditional IT adoption is extended to include the use-diffusion of technologies and emphasize use of the attributes of devices and systems of a single type of device constrained to a single situation (e.g., home) [62], [63] or a single type of IT system use (e.g., VoIP) unconstrained to any situations [64]. This study examines the use of distinct types of devices embedded with the same IT systems with differing levels of sophistication of attributes for the same set of tasks within and between situations. Accordingly, this study extends IT adoption in organizational contexts by highlighting the situations in which personal devices may be a substitute for or may complement organizational devices for use. It also highlights the need to discriminate between organizational IT systems, which may require restricted versus unrestricted access on personal devices when an individual operates within organization-controlled spaces versus spaces uncontrollable by the organization.

B. Practical implications

Our findings help to identify the strategic conditions in which cross-situational use defines a) IT adoption for personal and organizational purposes, b) device sophistication by attributes, c) discrimination of IT system applications to different tasks, and d) distinction between different types of PC devices embedded with the same IT system with differing levels of sophistication. In the PC devices industry, product managers are undoubtedly aware of the potential for cannibalization between devices embodying the same technology and may even plan for and expect it to occur. The rapid evolution of devices in the industry with the increasing sophistication and multi-functionality of smartphones and even e-readers means they are likely to cross category boundaries. For instance, there is no doubt that, currently, larger screen phones are easily substituted for tablets [13]. Although managers may plan for and even promote cannibalization across substitute categories as well as between upgraded generations within categories, evolution and concurrent device usage encourages not only obsolescence and waste but also a degree of device proliferation that is potentially costly to organizations that either purchase or subsidize the purchase of such devices.

The findings of this study show that the accumulation of more incumbent devices similar to a new one does not necessarily lead to the engagement of the new and the incumbent devices for the same tasks across situations. Rather, the performance of the new device relative to the incumbent devices leads to a greater application of the devices to the same tasks but more so in different than in same situations. However, within same situations in which the new and incumbent devices can perform such tasks, the new device is engaged similarly or to a greater extent compared with incumbents. These findings suggest that vendors of devices must focus on attribute- or feature-driven, more than product-driven, innovation to reduce product proliferation, waste, and obsolescence from either planned or unplanned cannibalization and should increase the relevance of devices in-use. In particular, emphasizing how the sophistication of specific attributes of the new device enhances the uses of incumbent ones in different situations can help to navigate technology transitions. Such sophistication may arise from, for instance, the convenient engagement of devices for tasks in specific situations or the high performance of specific IT system tasks (e.g., data capture, conversion, storage, and retrieval) in different formats across situations within or across devices.

In order for organizational IT adopters to avoid a waste of resources due to the obsolescence of devices, it is more cost efficient for organizations to allocate fewer resources to device acquisition for internal use. For instance, because various employees have different levels of sophistication in the IT domain, instituting and/or subsidizing a (BYOD) policy would increase productivity because users can work anywhere with the devices they feel most comfortable with. Of course, this policy must be accompanied by strict control of sensitive organizational information for security purposes. However, to stay up to date with trends in the evolving IT ecosystem, organizations must allocate more resources to IT systems and enterprise software development and its compatibility with IT interfaces for effective alignment with the PC ecosystem's infrastructure. This is important for employee productivity, customer engagement, quick competitive response, and effective partner alignment.

The study has a significant implication for organizational IT systems and enterprise software development in the PC ecosystem. The findings imply that developing IT systems and software that standardize IT use between multiple devices is more appropriate when use of such systems and software does not require organizational restrictions to guarantee information security. Considering that different devices may be employed in different situations for specific tasks under the same type of use, it is important for tasks captured in one format with one device (e.g., a lecture slide captured with tablet PC camera) to be easily accessible or convertible to another format on another device (conversion of texts in image to word format with a laptop). This will improve productivity and efficiency not only for organizational IT use but also for individual IT use. Further, IT system and software developers might also focus on the transformation of features of devices from tangible to intangible formats. Considering that users migrate their use of incumbent devices to the latest and more sophisticated devices, the transformation of features into software can facilitate incumbent device adaptation to the use of new devices and so avoid wastage of organization IT resources on the acquisition of devices whose full use and lifespan are usually curtailed by the introduction of new devices.

Finally, our findings have significant managerial implications for complementary service provision and consumption within the PC ecosystem. For instance, while Internet service may come at a fixed cost to organizations and individuals across use situations (e.g., office subscription, mobile subscription, and home subscription plans), the use of these services may overlap when an individual accesses them across situations for personal and organizational uses. Accordingly, complementary service providers and customers (e.g., organizations) may consider plans that allow for a shared cost of the service when the same user can access different subscription plans across situations. However, complementary service providers may consider expanding the accessibility of mobile service plans to cover multiple devices in situations where users have a subscription on one mobile device but the service is needed on multiple devices.

VII. CONCLUSION

The relationship between reversed and traditional IT adoptions remains an important phenomenon for scholars and practitioners interested in technology diffusion for personal and organizational uses. This study contributes to the understanding of this phenomenon by examining how cross-situational specialization of a new generation PC, i.e., a tablet, for the same type of use served by incumbent devices defines a) IT adoption for personal and organizational purposes, b) device sophistication by attributes, c) discrimination of IT system applications to different tasks, and d) distinction between different types of PC devices embedded with the same IT system with differing levels of sophistication. Most importantly, the study concludes that when newer generation personal mobile devices are substituted for incumbent devices in-use but the substitution works only imperfectly, continuation of traditional adoption of IT devices by individual users may be a reversed adoption for organizations. However, this reversed adoption is partial because individuals may employ both personal and organizational devices as substitutes and complements based on the situational sophistication of the attributes of the devices for organizational IT systems use rather than sophistication of the devices *per se.* We hope that this study will open avenues for researchers to study how multiple devices, from different generations co-exist or dominate between and within situations respectively to enhance or constrain the same types of use.

A. Limitations and future research

Like any other research, this study has several limitations. First, we examined cross-situational specialization within specialized and non-specialized use patterns of the static use-diffusion model. We did not include intense and limited uses of the static use-diffusion model because these two patterns examine cross-device intensification or limitation to types of use. Thus, these two patterns remain for future research to consider. Second, our study limited the CSS of the new device to learning and educational uses among tertiary-level education users to contextualize traditional and reversed IT adoption for end-users and organizations. Other types of uses, from entertainment and information management to communication management and social media, may offer different levels of skewness to IT system uses on devices across situations. These domains of use offer opportunities for future research to examine and to delineate the CSS of new technological devices.

Third, the cross-situational use in this study emphasized the application of PCs as bundles of hardware and IT systems/software for learning and educational uses. Extensions of this research might include other information technologies beyond hardware devices. For example, content and data storage, electronic payments, and social media apps all offer appropriate contexts for examining cross-situational uses. Fourth, the cross-sectional data for this study indicate that the relationships between variables in the model are associative rather than predictive. Further research could adopt a longitudinal approach to examine dynamic cross-situational uses of a given technology across time. Finally, this study examined the complementarity and substitutability relationships between new and incumbent devices across situations. Ongoing research could examine the independence of such devices across situations.

REFERENCES

[1] R. Adner, R. and R. Kapoor, “Innovation ecosystems and the pace of substitution: Re-examining technology S-curves,” *Strategic Management Journal*, vol. 37 no. 4, pp. 625-648, 2016.

[2] R. Adner, R. and R. Kapoor, "Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations," *Strategic Management Journal,* vol. 31 no. 3, pp. 306-333, 2010.

[3] A. A. Alalwan, Y. K. Dwivedi, and N. P. Rana, "Factors influencing adoption of mobile banking by Jordanian bank customers: Extending UTAUT2 with trust," *International Journal of Information Management*, vol. 37 no. 3, pp. 99-110, 2017.

[4] R. L. Anderson and D. J. Ortinau, "Exploring consumers' postadoption attitudes and use behaviors in monitoring the diffusion of a technology-based discontinuous innovation," *Journal of Business Research*, vol. 17 no. 3, pp. 283-298, 1988.

[5] P. Baillette, Y. Barlette, and A. Leclercq-Vandelannoitte. "Bring your own device in organizations: Extending the reversed IT adoption logic to security paradoxes for CEOs and end users," *International Journal of Information Management*, vol. 43, pp. 76-84. 2018.

[6] Y. Barlette, A. Jaouen, and P. Baillette, "Bring Your Own Device (BYOD) as reversed IT adoption: Insights into managers' coping strategies," *International Journal of Information Management*, vol. 56, pp. 102-212. 2021.

[7] F. M. Bass, "A new product growth for model consumer durables," *Management Science*, vol. 15, no. 5, pp. 215-227, 1969.

[8] A. Bhattacherjee and S. C. Park, "Why end-users move to the cloud: a migration-theoretic analysis," European Journal of Information Systems, vol. 23, no. 3, pp. 357-372, 2014.

[9] M. Blut and C. Wang, "Technology readiness: a meta-analysis of conceptualizations of the construct and its impact on technology usage," *Journal of the Academy of Marketing Science*, vol. 48, pp. 649-669, 2020.

[10] D. Böhning, "Multinomial logistic regression algorithm," *Annals of the Institute of Statistical Mathematics*, vol. 44, no. 1, pp. 197-200, 1992.

[11] A. A. Bush, A. Tiwana, and A. Rai, "Complementarities between product design modularity and IT infrastructure flexibility in IT-enabled supply chains," IEEE Transactions on Engineering Management, vol. 57, no. 2, pp. 240-254, 2010.

[12] E. D. Cassidy, A. Colmenares, G. Jones, T. Manolovitz, L. Shen, and S. Vieira, "Higher education and emerging technologies: Shifting trends in student usage," *Journal of Academic Librarianship*, vol. 40, no. 2, pp. 124-133, 2014.

[13] L. Chang, "Fewer people are buying tablets, and it's become a long-standing trend," *Digital Trends*, 2017. [Online] Available: https://www.digitaltrends.com/mobile/tablet-shipments-decline-again/

[14] S. L. Cohen and M. Tripsas, "Managing technological transitions by building bridges," *Academy of Management Journal*, vol. 61 no. 6, pp. 2319-2342, 2018.

[15] E. Dahlstrom, J. D. Walker, and C. Dziuban, "ECAR study of undergraduate students and information technology," In *EDUCAUSE Center for Applied Research*. Louisville, Kentucky, USA, 2013.

[16] P. J. Danaher, B. G. Hardie, and W. P. Putsis, "Marketing-mix variables and the diffusion of successive generations of a technological innovation," *Journal of Marketing Research*, vol. 38, no. 4, pp. 501-514, 2001.

[17] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS Quarterly*, vol. 13, no. 3, pp. 319-340, 1989.

[18] S. Dewan, D. Ganley, and K. L. Kraemer, "Complementarities in the diffusion of personal computers and the Internet: Implications for the global digital divide," *Information Systems Research*, vol. 21 no. 4, pp. 925-940. 2010.

[19] C. E. Downing, "System Usage Behavior as a Proxy for User Satisfaction: An Empirical Investigation," *Information & Management*, vol. 35, no. 4, pp. 203-216, 1999.

[20] Y. K. Dwivedi, N. P. Rana, A. Jeyaraj, M. Clement, and M. D. Williams, "Re-examining the unified theory of acceptance and use of technology (UTAUT): Towards a revised theoretical model," *Information Systems Frontiers*, vol. 21, pp. 719-734, 2019.

[21] R. J. Fisher and L. L. Price, "An investigation into the social context of early adoption behavior," *Journal of Consumer Research*, vol. 19, no. 3, pp. 477-486, 1992.

[22] Forbes, "The Future Of BYOD: Statistics, Predictions And Best Practices To Prep For The Future," [Online]. Available: https://www.forbes.com/sites/lilachbullock/2019/01/21/the-future-of-byod-statistics-predictions-and-best-practices-to-prep-for-the-future/, 2019.

[23] N. Franke and E. von Hippel, "Satisfying heterogeneous user needs via innovation toolkits: The case of Apache security software," *Research Policy*, vol. 32, no. 7, pp. 1199-1215, 2003.

[24] [24] K. L. Heinze and J. E. Heinze, "Individual innovation adoption and the role of organizational culture," *Review of Managerial Science*, vol. 14, pp. 561-586, 2020.

[25] M. Ganco, R. Kapoor, and G. K. Lee, "From rugged landscapes to rugged ecosystems: Structure of interdependencies and firms' innovative search," *Academy of Management Review*, vol. 45, no. 3, pp. 646-674, 2020.

[26] J. Gerlach, R. M. Stock, and P. Buxmann, "Never forget where you're coming from: the role of existing products in adoptions of substituting technologies," *Journal of Product Innovation Management*, vol. 31, no. 1, pp. 133-145, 2014.

[27] P. N. Golder and G. J. Tellis, "Beyond diffusion: an affordability model of the growth of new consumer durables," *Journal of Forecasting*, vol. 17, no. 3/4, pp. 259-280, 1998.

[28] J. K. Han, S. W. Chung, and Y. S. Sohn, "Technology convergence: when do consumers prefer converged products to dedicated products?" *Journal of Marketing*, vol. 73, no. 4, pp. 97-108, 2009.

[29] B. G. S. Hardie, T. S. Robertson, and J. W. T. Ross, Technology adoption: Amplifying versus simplifying innovations. *Marketing Letters*, vol. 7 no. 4, pp. 355-369, 1996.

[30] Y. E. Huh and S. H. Kim, "Do early adopters upgrade early? Role of post-adoption behavior in the purchase of next-generation products," *Journal of Business Research*, vol. 61, no. 1, pp. 40-46, 2008.

[31] R. Iyengar, A. Ansari, and S. Gupta, "A model of consumer learning for service quality and usage," *Journal of Marketing Research*, vol. 44, no. 4, pp. 529-544, 2007.

[32] A. D. Jankowicz, *Business research projects*. 4th ed. London, UK, Thomson Learning, 2005,

[33] Z. Jiang and D. C. Jain, "A generalized Norton–Bass model for multigeneration diffusion," *Management Science*, vol. 58, no. 10, pp. 1887-1897, 2012.

[34] O. Jokonya, "Towards a critical systems thinking approach during IT adoption in organisations," Procedia Computer Science, vol. 100, pp. 856-864, 2016.

[35] S. Kekre, M. S. Krishnan, and K. Srinivasan, "Drivers of customer satisfaction for software products: Implications for design and service support," *Management Science*, vol. 41, no. 9, pp. 1456-1470, 1995.

[36] N. Kim, D. R. Chang, and A. D. Shocker, "Modelling intercategory and generational dynamics for a growing information technology industry," *Management Science*, vol. 46, no. 4, pp. 496-512, 2000.

[37] W. J. Kim, J. D. Lee, and T. Y. Kim, "Demand forecasting for multigenerational products combining discrete choice and dynamics of diffusion under technological trajectories," *Technological Forecasting and Social Change*, vol. 72, no. 7, pp. 825-849, 2005.

[38] S. S. Kim, N. K. Malhotra, and S. Narasimhan, "Two competing perspectives on automatic use: A theoretical and empirical comparison," *Information Systems Research*, vol. 16, no. 4, pp. 418-432, 2005.

[39] W. C. Kim and R. Mauborgne, "Creating new market space," *Harvard Business Review*, vol. 77, no. 1, 83–93, 1999.

[40] P. Konana and G. Ray, "Physical product reengineering with embedded information technology," *Communications of the ACM*, vol. 50, no. 10, pp. 72-78, 2007.

[41] U. Kumar and V. Kumar, "Technological innovation diffusion: The proliferation of substitution models and easing the user's dilemma," *IEEE Transactions on Engineering Management*, vol. 39, no. 2, pp. 158-168, 1992.

[42] A. Leclercq-Vandelannoittea, "Managing BYOD: how do organizations incorporate user-driven IT innovations?" *Information Technology & People*, vol. 28, no. 1, pp. 2-33, 2015.

[43] A. Leclercq-Vandelannoitteb, "Leaving employees to their own devices: new practices in the workplace," *Journal of Business Strategy*, vol. 36, no.5, pp. 18-24, 2015.

[44] A. Leclercq-Vandelannoitte and E. Bertin, "From sovereign IT governance to liberal IT governmentality? A Foucauldian analogy," *European Journal of Information Systems*, vol. 27, no. 3, pp. 326-346, 2018.

[45] S. J. Mäkinen, J. Kanniainen, and O. Dedehayir, "Adoption dynamics of increasing-return technologies in systemic contexts," In *Proceedings of PICMET'11: Technology Management in the Energy Smart World, IEEE*, Portland, OR, USA, 2011, pp. 1-8.

[46] C. Middleton, R. Scheepers, and V. K. Tuunainen, "When mobile is the norm: researching mobile information systems and mobility as post-

adoption phenomena*,*" *European Journal of Information Systems*, vol. 23, no. 5, pp. 503-512, 2014.

[47] J. H. Mueller and K. F. Schuessler, *Statistical reasoning in sociology*, Boston, MA, USA: Houghton Mifflin, 1961.

[48] T. N. Q. Nguyen, L. V. Ngo, G. Northey, and C. A. Siaw, "Realising the value of knowledge resources and capabilities: an empirical study," *Journal of Knowledge Management*, vol. 23, no. 2, pp. 374-395, 2019.

[49] J. A. Norton and F. M. Bass, "A diffusion theory model of adoption and substitution for successive generations of high-technology products," *Management Science*, vol. 33, no. 9, pp. 1069-1086, 1987.

[50] M. Nouri-Harzvili, S. M. Hosseini-Motlagh, and R. Zirakpourdehkordi, "Evolutionary Marketing Strategies for New High-Technology Product Sales: Effects of Customers' Innovation Adoption*,*" *IEEE Transactions on Engineering Management*, pp. 1-14, 2022.

[51] J. C. Nunnally and I. H. Bernstein, *Psychometric theory*. 3rd ed. NY, USA, McGraw-Hill, 1994.

[52] C. Park, "Customers' migration paths decided by relative advantage: longitudinal and comparative case study of successive generations of logic semiconductor technology," *Technology Analysis & Strategic Management*, vol. 31, no. 9, pp. 1063-1080, 2019.

[53] M. E. Porter and J. E. Heppelmann, "How smart, connected products are transforming competition," *Harvard Business Review*, vol. 92, no. 11, pp. 64-88, 2014.

[54] L. L. Price and N. M. Ridgway, "Development of a scale to measure use innovativeness," *NA-Advances in Consumer Research*, vol. 10, pp. 679-684, 1983.

[55] R. Prins, P. C. Verhoef, and P. H. Franses, "The impact of adoption timing on new service usage and early disadoption," *International Journal of Research in Marketing*, vol. 26, no. 4, pp. 304-313, 2009.

[56] N. Rahman, T. Daim, and N. Basoglu, "Exploring the factors influencing big data technology acceptance," *IEEE Transactions on Engineering Management*, vol. 70, no. 5, pp. 1738-1753, 2021.

[57] D. Rangarajan, V. Badrinarayanan, A. Sharma, R. K. Singh, and S. Guda, "Left to their own devices? Antecedents and contingent effects of workplace anxiety in the WFH selling environment," *Journal of Business & Industrial Marketing,* vol. 37, no. 11, pp. 2361-2379, 2022.

[58] G. J. Russell, S. Ratneshwar, A. D. Shocker, D. Bell, A. Bodapati, A. Degeratu, L. Hildebrandt, N. Kim, S. Ramaswami, and V. H. Shankar, "Multiple-category decision-making: Review and synthesis," *Marketing Letters*, vol. 10, no. 3, pp. 319-332, 1999.

[59] E. M. Rogers, "*Diffusion of innovations*," NY, USA, The Free Press of Glencoe, 1962.

[60] K. Schmitz, J. T. Teng, and K. Webb, "Capturing the Complexity of Malleable IT Use: Adaptive Structuration Theory for Individuals," *MIS Quarterly*, vol. 40, no. 3, pp. 663-686, 2016.

[61] V. L. Senders, "*Measurement and statistics*" NY, Oxford University Press, 1958.

[62] C. F. Shih and A. Venkatesh, "Beyond adoption: Development and application of a use-diffusion model," *Journal of Marketing*, vol. 68, no. 1, pp. 59-72, 2004.

[63] E. Shih, A. Venkatesh, A., and E. Kruse, "Dynamic use diffusion model in a cross-national context: a comparative study of the United States, Sweden, and India," *Journal of Product Innovation Management*, vol. 30, no. 1, pp. 4-16, 2013.

[64] Y. W. Shih, Y. L. Wu, Y. S. Wang, and C. L. Chen, "Investigating the post-adoption stage of Voice over Internet Protocol (VoIP) telephony diffusion: A use-diffusion approach," *Information Technology & People*, vol. 30, no. 4, pp. 753-784, 2017.

[65] A. D. Shocker, B. L. Bayus, and N. Kim, "Product complements and substitutes in the real world: The relevance of "other products"," *Journal of Marketing*, vol. 68, no. 1, pp. 28-40, 2004.

[66] M. Son and K. Han, "Beyond the technology adoption: Technology readiness effects on post-adoption behavior," *Journal of Business Research*, vol. 64, no. 11, pp. 1178-1182, 2011.

[67] R. K. Srivastava, M. I. Alpert, and A. D. Shocker, "A customer-oriented approach for determining market structures," *Journal of Marketing*, vol. 48, no. 2, pp. 32-45, 1984.

[68] R. K. Srivastava, R. P. Leone, and A. D. Shocker, "Market structure analysis: Hierarchical clustering of products based on substitution-in-use," *Journal of Marketing*, vol. 45, no. 3, pp. 38-44, 1981.

[69] Y. Sun, Z. Ding, and Z. Zhang, "Enterprise social media in workplace: innovative use cases in China," *IEEE Transactions on Engineering Management*, vol. 70, no. 7, pp. 2447 - 2462, 2020

[70] M. Tarafdar and H. Tanriverdi, "Impact of the Information Technology Unit on Information Technology-Embedded Product Innovation," *Journal of the Association for Information Systems*, vol. 19, no. 8, pp. 716-751, 2018.

[71] H. P. VanDerSchaaf, T. U. Daim, and N. A. Basoglu, "Factors influencing student information technology adoption," *IEEE Transactions on Engineering Management*, vol. 70, no. 2, pp. 631-643, 2021.

[72] S. L. Vargo, M. A. Akaka, and H. Wieland, "Rethinking the process of diffusion in innovation: A service-ecosystems and institutional perspective," *Journal of Business Research*, vol. 116, pp. 526-534, 2020.

[73] V. Venkatesh and F. D. Davis, "A theoretical extension of the technology acceptance model: Four longitudinal field studies," *Management Science*, vol. 46, no. 2, pp. 186-204, 2000.

[74] V. Venkatesh, M. G. Morris, G. B. Davis, and F. D. Davis, "User acceptance of information technology: Toward a unified view," *MIS Quarterly*, 425-478, 2003.

[75] V. Venkatesh, J. Y. Thong, and X. Xu, "Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology," *MIS Quarterly*, pp. 157-178, 2012.

[76] P. Ziamou and S. Ratneshwar, "Promoting consumer adoption of high-technology products: Is more information always better?" *Journal of Consumer Psychology*, vol. 12, no. 4, pp. 341-351, 2002.

[77] P. Ziamou and S. Ratneshwar, "Innovations in product functionality: When and why are explicit comparisons effective?" *Journal of Marketing*, vol. 67, no. 2, pp. 49-61, 2003.

Christopher Agyapong Siaw is Lecturer in Marketing at the Plymouth Business School, University of Plymouth, UK. He has taught extensively across marketing, management and strategy disciplines in various universities including Sydney University and UNSW in Australia. With a core research interest in how customer value drives firm value creation processes, Christopher's research focuses on knowledge management and co-creation of value in ecosystems, new product innovation and technology transitions, product market structures and evolution, and societal marketing. His research has appeared in journals such as *European Journal of Marketing*, *Journal of Business Research, Journal of Knowledge Management, and Strategic Change*.

Jack Cadeaux is a Professor of marketing at the University of New South Wales, Sydney, Australia. He is an editorial board member for Journal of Macromarketing and Australasian Marketing Journal. His research focuses on retail assortments, retail stock planning and retail performance; distribution and supply chain management; entrepreneurial marketing, marketing strategy, new product development, and marketing aspects of innovation; macromarketing, public policy and consumption externalities. His research has appeared in world leading journals such as *Decision Sciences, European Journal of Marketing, Industrial Marketing Management, International Journal of Operations and Production Management, International Journal of Production Economics, Journal of Business Research, Journal of Macromarketing, and Journal of Public Policy & Marketing*.

Dirk Meissner is Distinguished Professor, Head of the Laboratory for Economics of Innovation at HSE ISSEK and Academic Director of the Master's Programme "Science, Technology and Innovation Management and Policy". Dr. Meissner has 25 years' experience in research and teaching technology and innovation management and policy. He has

strong background in policy making and industrial management for STI. He is Associate Editor of Technological Forecasting and Social Change, IEEE Transactions on Engineering Management, Journal of Intellectual Capital, Journal of the Knowledge Economy, member of Editorial Review Board at Small Business Economics and Journal of Knowledge Management. He guest-edited Special Issues in Industry and Innovation Journal, Journal of Engineering and Technology Management, Technological Analysis and Strategic Management among others.

Adrian Payne is Emeritus Professor in marketing at the University of New South Wales. Adrian has a special interest in the use of executive education to help boards and senior Management implement their strategy and their strategic initiatives. He is an author of fourteen books including the first text to be published on Relationship Marketing. A recent study from Stanford University has recognised Adrian as one of the Global Top 2% of scientists and scholars. His research focuses on work that is pragmatic, relevant and applied to customer centricity, professional service firm marketing, CRM strategy, customer retention and customer advocacy. He has published extensively including 90 refereed articles. His work is highly cited with over 25,000 citations and his research has appeared in many leading journals, including the *Journal of Marketing, Journal of the Academy of Marketing Science, Journal of Service Research, Industrial Marketing Management, Journal of International Business Studies*, etc. He has won various awards and prizes including the prestigious *Journal of Marketing/ Sheth Foundation* award for a best paper that makes a long-term contribution to the field of marketing.

David Sarpong is a Professor in Strategic Management and the Head of Marketing and Strategy Department at Aston University Business School, Birmingham, UK. Drawing on 'practice' as a meta-theoretical lens, his research interest lies in the broad areas of strategic management and international management. His current research concerns innovation management, strategic foresight, process theory, relational-ism and the micro-historia of first generation west-African migrants in European cosmopolitan marketplaces. His research has appeared in journals such as *Technovation, Technological Forecasting and Social Change, International Marketing Review, Work Employment and Society, European Urban and Regional Studies, and Journal of Business Research*.