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Model of Migration and Use of Platforms: Role of Hierarchy, Current Generation, and Complementarities in Consumer Settings

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We develop and test a model of migration and use of platforms to explain consumers' reactions to the newest generation of an information and communication technology platform. We draw from information systems and consumer behavior research on adoption and use of technologies, and adapt and incorporate the construct of complementarity from macrolevel research on platform leadership, network effects, and innovation ecosystems. We conceptualize complementarities between the hardware and software platforms, software platform and applications, and applications and services. The complementarities are theorized to influence migration intention, with current generation of the consumer's platform being a key moderator. We empirically validated our model with data collected using two waves of surveys from 4,412 consumers (2,333 consumers in the second wave) before and after the introduction of the third generation (3G) mobile data services platform in Hong Kong. We explained 60% of the variance in migration intention that in turn was strongly correlated with migration to and use of 3G.

Key words: technology hierarchy; technology complementarity; platform migration; service innovation; service management; IT adoption and diffusion
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1. Introduction and Research Motivation

Advances in computing have allowed firms to provide high-quality, diversified, and personalized services more easily and affordably than ever before. This is particularly true in the case of information and communication technology (ICT) services[1] because of the unique cost structure of ICT—i.e., high development costs and low distribution costs (Bakos and Brynjolfsson 1999, Hitt and Chen 2005, Shapiro and Varian 1999). This cost-effective diversity in services is most evident in the consumer markets, because service innovations enabled by new generations of ICTs enhance both revenue and competitive advantage for ICT service providers (Dewan et al. 1998). With future services for consumers, such as mobile wallets, projected to have 10 to 25 million users by 2011 (Chamberlain 2006c), consumer adoption and use of such services are important to the success of the ICT ecosystem. In response to the rapid innovations and explosion of services, there have been calls for research on ICT services and their management (Rai and Sambamurthy 2006).

To foster the creation of new services, new generations of ICT platforms—i.e., hardware and software that support service innovation—are constantly rolled out. For instance, in the mobile communication market, the second generation (2G) platform has been replaced by new generations, i.e., 2.5G, 2.75G, and 3G, within the past 10 years. Whereas 2G mobile data services (MDS) consist only of short

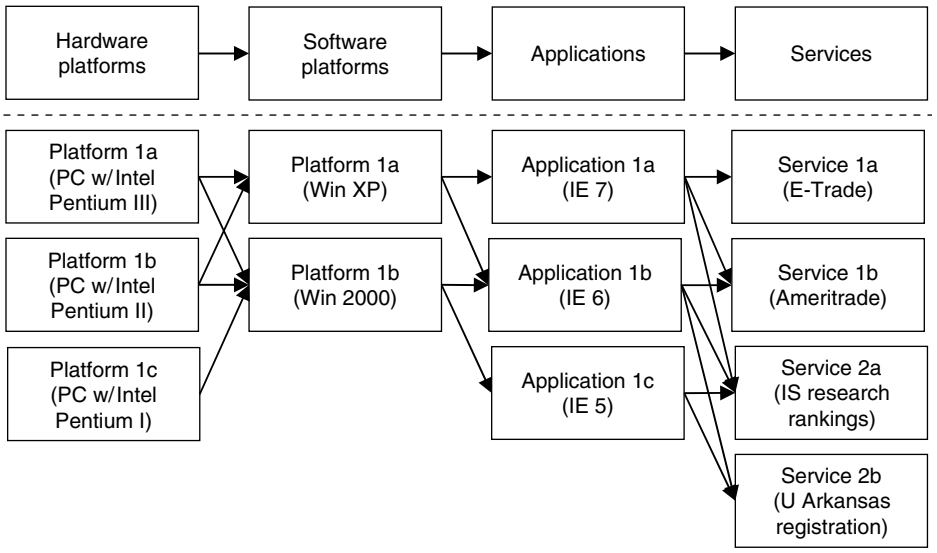
[1] We define an ICT service as an ICT-enabled provider–client interaction that creates and captures value (IBM Research 2004). We focus on ICT services for consumers, i.e., services with which consumers have direct interactions.

messaging services (SMS) and wireless access protocol (WAP) Internet browsing, 3G offers a wide range of MDS—e.g., video services, location-based services, and mobile business solutions. The rapid evolution has led to the coexistence of multiple generations of platforms at any point in time, with consumers distributed along the diffusion curves of different generations. These platform generations compete with and complement each other to meet consumers' needs (Danaher et al. 2001). Thus, when a new platform generation is introduced, ICT service providers face a significant challenge in marketing service innovations (Chamberlain 2006a, b; Rai and Sambamurthy 2006) and fostering success for both organizations and consumers (Rai et al. 2002). At the macro level, this issue is important because the introduction of a new generation of an ICT platform usually implies a large investment in research and development, infrastructure deployment, and licensing fees—e.g., the total 3G licensing fee was around USD 100 billion by 2002.

Consumer adoption and use of ICT service innovations are seldom decisions made in isolation. Instead, these decisions involve the evaluation of a platform and a system of related technologies because ICT artifacts are built on a metaphor of a layered system in which technologies in the lower layer serve as the platform (e.g., hardware) on which technologies in the upper layer (e.g., software applications) function (Gawer and Cusumano 2002, McGrath 1995). An ICT platform refers in general to a set of subsystems and interfaces that form a common structure for/from which derivative applications can be developed and distributed (McGrath 1995). To access an ICT service, a consumer needs lower-layer technologies—i.e., a particular application, a particular software platform, and a specific hardware platform/device. These technology layers form a *hierarchy*, shown in Figure 1. For example, to access a traditional Internet-based service (e.g., E-Trade stock trading service; service 1a), a user will need a specific application (e.g., Internet Explorer, version 7; application 1a) that in turn could require a specific software platform (e.g., Windows XP; software platform 1a) that in turn may have certain minimum hardware device requirements (e.g., a computer with an Intel 2.00 GHz chipset; hardware platform 1a). Therefore, consumer decision making about service innovations hinges on their evaluation of the platform because the diversity and performance of services are largely determined by the capabilities of and interactions among all the layers in the hierarchy. Indeed, both academic and trade press articles on platform leadership and service innovation have suggested the need for firms to coordinate *complementary* innovations at different technology layers from third-party vendors to gain maximal benefits in market share and profits (e.g., Adner 2006, Church and Gandal 1993, Gawer and Cusumano 2002, UMTS Forum 2006).

As services in the top layer function on the lower-layer technologies, a fundamental change in any of the lower layers results in a chain reaction in the industry (Gulati et al. 2003, Lyytinen and Rose 2003). Thus, when a new ICT platform generation is introduced, the speed and magnitude of its diffusion largely determine the survival and success of all the stakeholders in the value chain—e.g., service providers, content and application developers, software platform developers, and infrastructure and device manufacturers.

Figure 1 Technology Hierarchy



Notes. For each given number within a specific component of the hierarchy, the letters represent competing generations/versions (alternatives). The associations shown from hardware platforms to software platforms to applications to services are for illustrative purposes.

It is thus important to the entire value chain to understand consumer adoption of a new ICT platform generation because consumption of services represents the ultimate source of revenue (see Gulati et al. 2003) and the success of services often hinges on the consumer *migration to the new platform generation*.

Related to the phenomenon of interest, we found two broad streams of research upon which to build. The first stream focuses on consumer adoption and use of technologies (e.g., Venkatesh and Brown 2001). The second stream is macrolevel work on complementarities (e.g., Milgrom and Roberts 1990), with different labels, such as platform leadership (Cusumano and Gawer 2003), innovation ecosystem (Adner 2006), and indirect network effects (e.g., Church and Gandal 1993). Although there are several models of consumer adoption and use of technologies, with innovation characteristics being the primary predictors (e.g., Venkatesh and Brown 2001), this body of work (1) treats technologies as singular and independent, and (2) overlooks the existence of overlapping technology generations. Specifically, prior work on consumer adoption focuses on a single technology artifact, such as a hardware platform/device (e.g., Venkatesh and Brown 2001), a software application (e.g., Agarwal et al. 1997), or a service (e.g., Venkatesh and Agarwal 2006). In contrast, we expect consumers' decisions about the adoption and use of platforms to involve the evaluation of multiple interdependent technologies in the hierarchy. The macrolevel research on this topic has focused on one common theme—the central role of the complementarities among technologies across the value chain. That work has addressed strategic issues, such as risk management (Adner 2006) and software development support (Church and Gandal 1993). However, it has mainly focused on the generic hardware/software paradigm (e.g., Katz and Shapiro 1994) or the platform–application dichotomy (e.g., Gupta et al. 1999), with little or no consideration given to the entire hierarchy, i.e., hardware platforms, software platforms, applications, and services. Thus, the first scientific gap we seek to address in this work is to understand consumer migration to the latest generation of an ICT platform.

We identify a second gap in the literature on the adoption and use of technologies. The notion of technology generations is ubiquitous, yet it has not been explicitly considered in prior work. Instead, technology has been treated as a "single generation" and a standalone element (e.g., PC, Windows OS) and, thus, modeled as a static and independent entity. Such a view overlooks the *evolutionary* nature of technology. Many technologies evolve over time, with the addition of new features. These changes can be characterized along a spectrum, with one end signifying incremental changes and the other end representing discontinuous technological breakthroughs. For instance, whereas the 2.5G platform is an incremental upgrade to the 2G, the 3G (relative to the 2G) is a technological breakthrough characterized by architectural change in infrastructure and fundamental improvement in the service portfolio (Tilson and Lyytinen 2005). In most prior research, the decision of interest was whether to go from *no technology* to a *new technology* (e.g., Szajna 1996), whereas other research examined contexts where users go from an *existing technology* to a *new technology* (e.g., Rai and Patnayakuni 1996). Yet, when understanding the adoption decision, little or no consideration was given to the existing technology and, more importantly, to the difference in the extent of change between the old and new technologies. We argue that a consumer's *current technology generation*, which we use to conceptualize the extent of change facing the consumer, will play a role in his or her decision to migrate to the newest generation. Evidence of this exists in research on models of innovation diffusion at the macro/market level that has explicitly considered overlapping generations and identified different consequences—e.g., cannibalization and enhancement effects (e.g., Danaher et al. 2001, Pae and Lehmann 2003).

We theorize the migration to a new technology generation (e.g., 3G) as a *decision* that considers the *complementarities, i.e., synergies, across the hardware platform–software platform–application–service hierarchy*. Specifically, we suggest complementarities, which focus on the efficient, effective, and smooth interactions across layers in the technology hierarchy, shown in Figure 1, will play a key role in consumer migration decisions regarding the new ICT platform as high complementarities create maximal value for users (Adner 2006). We will also argue that the complementarities will play differential roles depending on the extent of change expected as a result of the migration. Against this backdrop, this paper has the following objectives:

1. Develop a model of migration and use of platforms (MoMnUP) to explain how and why consumers migrate and/or use the newest generation of an ICT platform.

2. Empirically validate the proposed models in a naturally occurring field setting concurrent with the introduction of a new ICT platform.

Our work is expected to make three key theoretical contributions. First, we deepen our understanding of consumer migration and use of a new generation of an ICT platform by bringing a new theoretical lens related to complementarities to augment prior work, which has drawn primarily from psychology and sociology research. Second, we incorporate the extent of change from the current generation (from which

a consumer migrates) to the newest generation of a technology into the nomological network regarding consumer adoption and use decisions, and argue that the drivers of consumer migration and use decisions vary depending on the extent of change. Finally, we contribute to research on platform leadership and technology ecosystems by conceptualizing complementarities at a micro level and demonstrating its role in the consumers' decision making regarding new ICT platforms.

2. Model Development

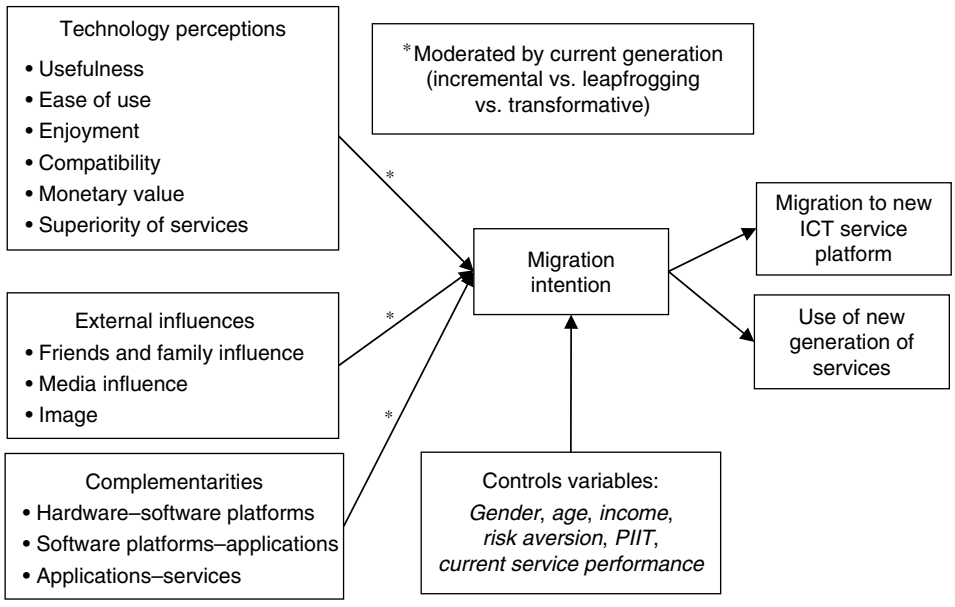
Figure 2 presents our MoMnUP. The key new constructs introduced in this work are the three different complementarities across layers in the technology hierarchy. Also, we discuss the role of the user's current generation (extent of change) as a moderator of various relationships. Although our primary focus is on complementarities, any model of consumer adoption and use of any sort of technology must consider the prior research on this topic that has investigated various technology perceptions and social influences, which are not formally hypothesized but included in the MoMnUP. We discuss these first.

2.1. Technology Perceptions

When a new ICT platform generation is introduced, consumers will estimate overall gains from migration and *update* their beliefs about different aspects of *ICT services on the new ICT platform generation*. Although migration and adoption are not equivalent, they are similar in that both involve evaluation of technologies. Therefore, prior technology adoption research can be leveraged to identify relevant technology perceptions. From this literature base, we identified two constructs that have repeatedly played a role in technology adoption decisions, be it in the home or the workplace: *usefulness* and *ease of use* (see Venkatesh 1999, Venkatesh et al. 2003, Venkatesh and Brown 2001). Usefulness is defined as the degree to which an individual believes that using the technology (i.e., ICT platform) will help him or her to attain gains in personal productivity (Venkatesh and Davis 2000). The greater the expected productivity gains, the greater the intent to migrate to the new platform. Ease of use is defined as the degree to which an individual believes that using the new platform will be free of effort (Venkatesh and Davis 1996). The novel technological content embodied in new services may unleash new interfaces that may make consumers' knowledge about older platforms obsolete and demand substantial effort to learn and use the new platform. The lower the expected level of effort, the greater the intent to migrate.

Another practical consideration relates to cost. The price–value trade-off is a construct that we label *monetary value*, which is typically an important consideration in consumer decisions, including technology adoption decisions (Venkatesh and Brown 2001). Monetary value is defined as a consumer's cognitive trade-off between the quality and performance of the new platform and the monetary sacrifice for using it (adapted from Dodds et al. 1991). Out-of-pocket cost (i.e., price) has been shown to be "overweighted" relative to opportunity cost (e.g., Thaler 1980). Consumers usually need to pay either a price to acquire the new hardware and/or pay a premium for

Figure 2 Research Model, MoMnUP



upgrades and/or pay for new services facilitated by the platform. Such costs are expected to be influence consumer decisions vis-à-vis the value they perceive to derive from adopting and using the new platform.

In nonwork settings, variations of the construct of *enjoyment* from using the technology have been found to be important (van der Heijden 2004, Venkatesh and Brown 2001). Enjoyment is defined as the extent to which the act of using the new ICT platform is perceived to be pleasurable in its own right, apart from any expected performance consequences (Venkatesh 2000). With regard to the role of enjoyment, because of its potential to create new services, a new ICT platform generation can have ramifications for enjoyment. Further, the potential for novel services may explicitly invoke or heighten enjoyment.

Compatibility, defined as the degree to which an innovation is perceived as being consistent with the existing values, needs, and past experiences of potential adopters, has been shown to influence technology adoption (Venkatesh et al. 2003, Rogers 1995). The fit between a new platform and the services that it can enable on the one hand and one's lifestyle and values on the other hand will be important to consumers. For instance, SMS for communication and multimedia messaging services (MMS) for experience sharing anytime, anywhere can be appealing to those consumers who lead fast-paced lives. The more a consumer perceives a fit between the new ICT platform and his or her lifestyle, the greater the likelihood that he or she will migrate.

The last technology perception relates to services that will be facilitated by the new platform. We label this construct as the *superiority of services* and define it as the extent to which the new platform is expected to support and provide services that are better than those available in an existing platform generation. As multiple technology platform generations coexist at any point in time, consumers will make comparisons between the new and old generations. These comparisons will involve the evaluation of the gains expected in the service layer. For instance, when comparing the 3G with the 2.5G, broadband data capabilities and improvements in device functionalities serve as a way to improve existing services, such as messaging (from text and picture to video messaging), and create new services, such as mobile TVs and mobile business solutions (Tilson and Lyytinen 2005).

2.2. External Influences

External influences represent the collection of perceived pressures exerted by extraindividual sources. We identify and define three key external influences based on prior research (see Venkatesh and Brown 2001, Venkatesh et al. 2003): *friends and family influence*, *media influence*, and *image*. Friends and family influence is defined as the degree to which an individual perceives that important others believe he or she should use the target technology, here the new platform. Media influence is defined as the degree to which a consumer perceives that the mass media, such as TV and newspapers, advocate that he or she should use the new platform. Image is defined as the perceived gain in social status from adoption of the new platform.

The impact of various external influences on consumer behavior is well documented (e.g., Reingen and Kernan 1986). Consumers may base their decisions on the opinions of peers and senior members in their social group (Brown and Venkatesh 2005). When faced with a decision to migrate to new ICT platform generation, consumers can be expected to defer to others' opinions. Media influence is a key driver of purchase intent and decisions (e.g., Campbell and Keller 2003, Moschis and Moore 1982). Secondary sources, such as TV and radio, have been found to be a significant determinant of household technology adoption decisions (Venkatesh and Brown 2001). To promote a new platform and associated services, firms launch marketing campaigns through the mass media. In addition to advertisements, media outlets provide reviews by analysts and experts that typically tend to create hype around the new platform generation. Using the latest platform has the potential to enhance one's image in the peer group and creates both expert and referent power bases (Venkatesh and Davis 2000).

2.3. Perceptions of Complementarities

2.3.1. Definition. The concept of *complementarity* is multifaceted. Complementarity in economics is defined in terms of cross-price elasticity (Pindyck and Rubinfeld 2001), emphasizing the effect of price changes on demand for complementary goods. Goods or services are considered complements if an increase (decrease) in the price of one good or service leads to a decrease (increase) in the demand for the other.[2] In consumer behavior, complementarity is based on product- or feature-specific utilities and their fit with consumer needs. Complementary products (or features) are chosen by consumers to fill different aspects of their composite needs. For instance, toothpaste that offers both tartar protection and cavity prevention tends to be more attractive to consumers because complementary products have additive, positive effects

[2] For instance, if the price of mobile video phones drops, the demand for MMS may increase because mobile video phones and MMS are consumed together, and the total cost of using MMS is decreased. This is in contrast to substitutes, where an increase (decrease) in the price of one good or service results in the increase (decrease) of demand for the other (e.g., MP3 players and music mobile phones).

(i.e., $1 + 1 = 2$) on consumer reactions (Chernev 2005). Although this conceptualization addresses the consumer-utility side more directly, it still does not focus on the *synergy among complements* (i.e., $1+1 > 2$).

A key study of complementarity as a synergy among technologies was conducted by Milgrom and Roberts (1990). Their study of modern manufacturing identified the positive feedback effects among technology factors on the supply side, particularly the development of computer networks, computer-aided design (CAD), and robots or programmable equipments. They pointed out that because the three technologies are mutually reinforcing, only when they are adopted together can the efficiency and profitability of modern manufacturing be maximal. For example, to achieve the *maximum* benefits of flexible manufacturing, such as greater size of product lines and shorter production runs, CAD and programmable machinery must be adopted together such that the reconfiguration instructions generated from the CAD software can be readily applied to adjust the robots. Here, the readily applicable codes serve as the glue between the CAD software and the robots, which makes their interaction more efficient and effective. This accelerates the whole process from design modification to final production, which makes manufacturers more capable of meeting ever-changing market demands. Further, other benefits of flexible manufacturing, such as lower inventory through meeting consumer demand better and more quickly, can only be achieved when computer networking and other complementary market analysis software are installed together such that the business has more accurate and updated information about demand. Without any one of the three technology enablers, flexible manufacturing would be significantly less efficient and profitable due to bottlenecking.

Although originally developed to address macro (e.g., organizational) issues in manufacturing settings, the concept of complementarities in Milgrom and Roberts (1990) can be adapted to the micro (i.e., individual) level by focusing on the utility or value consumers can enjoy from complementarities across different layers of the technology hierarchy. In this research, we focus on the artifacts in the technology hierarchy and define *complementarities as the synergy between technologies in lower and upper layers that can provide value to end users through the efficient and effective interactions between the two layers*.[3] Analogous to complementarities in manufacturing technologies, which ultimately lead to greater profitability through greater efficiency, for the individual consumer, the synergy among different technology layers can produce greater utility or value than any single or isolated technology layer. We propose four related yet distinct facets of complementarity—namely, variety, smoothness, efficiency, and effectiveness—that together conceptualize the synergies described by the construct. For instance, to enjoy the maximum utility from real-time experience sharing[4] enabled by the 3G mobile network, consumers will need a mobile phone that has a high-quality video camera (hardware platform), an enhanced operating system supporting faster data transmission (software platform), a superior video capturing software (application), and the advanced MMS (service) offered by mobile carriers. Lacking any one of the above will make real-time experience sharing less appealing to consumers. For instance, without MMS, a consumer has to record his or her experience on a mobile phone and share it with friends only after plugging into a traditional PC with Internet capability (and e-mailing or uploading the video), thus hindering the very idea of sharing a real-time experience. Much like the efficient interaction between CAD software and robots serving as the source of benefits of flexible manufacturing, the efficient and effective interactions between any two technology layers create synergy and, thus, greater utility or value gains for consumers. For instance, much like the reconfiguration instructions enhanced the power of CAD software and programmable robots, a new mobile operating system that has an upgraded video driver can unleash the power of the latest model of a video camera on a mobile phone.

The concept of fit and synergistic gains is pervasive in individual-level research, albeit not in terms of complementarities of interrelated technology layers. For instance, Goodhue and Thompson (1995) highlighted the fit between task and technology as a prerequisite of workers' performance gains. This can be regarded as an application of the more general notion of complementarities (i.e., among technology, strategy, and organization) in Milgrom and Roberts (1990) to the micro (individual) level. However, Goodhue and Thompson (1995) did not consider the fit across layers in the technology hierarchy, perhaps because their study was conducted before times when ICTs evolved into the layered systems that they are today, with a great deal of interdependence across the layers and with different vendors focusing on different layers. Because ICTs have penetrated the consumer market with different vendors providing different

[3] Here, it is important to distinguish complementarity from compatibility—the former emphasizes synergy among technology layers, and the latter is about technologies fitting with an individual's lifestyle and/or values (Venkatesh et al. 2003).

[4] A typical example of real-time experience sharing is an individual using his/her mobile phone to film a video of what he or she is experiencing, such as a sunset, and stream the video in real time to his or her friends using the same phone.

layers of technology, technology–technology fit (i.e., technology complementarities) is likely a prerequisite to the task–technology fit that is necessary for performance benefits. For example, although a mobile device fits the task of navigation guide, the efficiency cannot be fully realized without a fit across various technologies, such as location-based services, global positioning systems, and high-speed data transfer to provide the real-time and detailed map information for consumers.

2.3.2. Effects of Complementarities on Migration Intention. We expect consumers will migrate to a new ICT platform generation only if they see significant synergistic gains across the different layers in the technology hierarchy. This is because a new generation of a lower-layer technology (platform)—e.g., 3G—will only be of maximum value to end users when accompanied by innovations in other technology layers, such as applications and services. For example, as depicted in Figure 1, when a new generation of a software platform (e.g., Windows Vista) is introduced, consumers will be not only interested in the new features of the software platform (e.g., Flip 3D), but also concerned about whether the software platform will work well with the hardware platform that they have, and new applications and services, such as Internet Explorer 7 and e-commerce services, that leverage the software platform. The importance of this type of synergy has been discussed in different streams of research, such as platform leadership (Gawer and Cusumano 2002), the innovation ecosystem (e.g., Adner 2006, Adner and Kapoor 2006), and network effects (e.g., Church and Gandal 1993, Katz and Shapiro 1994).

At the industry level, research on platform leadership has focused on organizational strategy and management practice (e.g., Gawer and Cusumano 2002). For example, Intel's platform leadership success has been attributed to the visionary coordination of external innovations that ensures a continuing supply of externally developed complementary products for the Intel platform. Other cases of platform leadership and associated successes include Microsoft, Cisco, and NTT DoCoMo (Cusumano and Gawer 2003). Similarly, research on the innovation ecosystem has emphasized the importance of complementary innovations across different layers of the ecosystem. For example, Adner (2006) and Adner and Kapoor (2006) argued that when complementarities exist, the efficient and effective interactions among different innovations can create value that no single innovation can provide. In addition, the timing of complementary innovations being available was identified as being important for risk management. Delayed complementary innovations can jeopardize the overall ecosystem because of the changes in the environment, such as changes in user preferences and the emergence of substitutes or new technologies.

The role of complementarities in determining technology adoption has also been extensively examined in the economics literature on indirect network effects (e.g., Church and Gandal 1993, Gandal et al. 2000). Network effects refer to the value of a particular technology to one user depending on the number of other users who adopt it (Shapiro and Varian 1999). Two categories of network effects, namely direct and indirect effects, have been identified in prior research. Direct effects are those directly determined by the number of end users of a particular technology. For example, the value of a telephone system to an end user depends on how many other users also use the same telephone system. Indirect effects refer mainly to the impacts of the variety of complementary innovations on the value of the focal technology (e.g., Church and Gandal 1993). For instance, the value of the Windows Vista software platform depends on the diversity of other software applications, such as the word processor, spreadsheet, media player, and games, that are developed for it. The greater the variety, the greater value of the software platform in the end-user market because heterogeneous needs can be satisfied to a greater extent. There have been analytical (e.g., Church and Gandal 1993) and empirical studies (e.g., Gandal et al. 2000) that emphasized the impacts of such complementarities. For instance, Church and Gandal (1993) showed that the value of hardware and, thus, its market share are enhanced as the variety of complementary software increases; similarly, the hardware–software complementarities influenced the diffusion of CDs (Gandal et al. 2000).

We focus on the complementarities across the four layers identified in the technology hierarchy—services, applications, software platform, and hardware platform. These four layers are the most visible ones to consumers. Although there may be other layers, such as application programming interface or software development kit, these are typically combined with the software platform and only visible to application developers. Because the introduction of complementary innovations is usually spread over time (Katz and Shapiro 1994), consumers' expectations of variety determine the extent to which their idiosyncratic needs can be satisfied. For example, the greater the diversity of applications for a particular software platform, the higher the probability that different consumers' needs can be met, and the higher the chance that a consumer will choose the software platform (Gandal et al. 2000, Gupta et al. 1999). A related example—one of the reasons for the slow uptake of high-definition TVs is the slow production of high-definition TV content (Adner 2006), a trend that we see reversing as more such content

becomes available. Expected smoothness, effectiveness, and efficiency represent end-users' beliefs about whether complementary innovations in the upper layer can utilize the capability of innovations in the lower layer—e.g., if the new mobile software platform can run smoothly, effectively, and efficiently on 3G mobile devices—to provide satisfactory performance. Low-quality complementary applications may lead to failure of the platform, as was the case with the Atari gaming platform that was tarnished by the poor-quality games flooding the market (Eisenmann et al. 2006). We propose that perceptions of each of the three key *complementarities—i.e., between the hardware and software platforms, between the software platform and applications, and between the applications and services*—will positively influence consumers' platform migration intention. Therefore, we hypothesize the following:

Hypothesis 1A (H1A). *Complementarities between the hardware platform and software platform will positively influence a consumer's migration intention.*

Hypothesis 1B (H1B). *Complementarities between the software platform and applications will positively influence a consumer's migration intention.*

Hypothesis 1C (H1C). *Complementarities between applications and services will positively influence a consumer's migration intention.*

2.4. Moderating Effects of Technology Generation

We theorize that the effects of various predictors in the MoMnUP will be moderated by the current technology generation that a consumer is using. To theorize the moderating effects of technology generation on technology perceptions and external influences, we draw primarily from Rogers' (1995) work on innovation diffusion and Moore's (1999) work on the cracks and the chasm in the adoption bell curve. For the moderated effects of complementarities, we draw mainly from research on consumer knowledge (e.g., Alba and Hutchison 1987) and consumer learning by knowledge transfer (e.g., Gregan-Paxton and John 1997, Moreau et al. 2001).

Although much prior work has focused on explaining adoption in single innovations, it provides a basis to study migration behavior from different generations of an ICT platform. Both Rogers (1995) and Moore (1999) argued that the adoption decision is not only influenced by innovation attributes but also by adopter categories. Five categories of adopters were defined based on the timing of adoption: innovators are venturesome and adopt innovations at the earliest stage; early adopters are opinion leaders, whereas early majority and late majority are people who need to deliberate and are even skeptical about innovations; and, finally, laggards are the most conservative people who rely almost solely on the past and are very resistant to change (see Brown and Venkatesh 2003, Moore 1999). Rogers (1995) simplified the adopter categorization and pointed out distinctions between two general categories—earlier adopters (innovators and early adopters) and later adopters (early majority, late majority, and laggards)—in terms of socioeconomic status, personality, and communication behavior. Particularly, earlier adopters are wealthier, have a more favorable attitude toward change, are more innovative and risk taking, and have greater ability to deal with abstractions and uncertainty. They serve as opinion leaders, seek novelty, and possess a lot of computer experience (Chau and Hui 1998). In contrast, later adopters seek press endorsement (Brown and Venkatesh 2003), suggesting that consumers who are using earlier generations of an ICT platform are subject to greater media influence.

Moore (1999), based on research on organizations, noted that there are three cracks and a chasm in the adoption bell curve. The cracks are between the innovators and early adopters, early majority and late majority, and late majority and laggards, respectively. The chasm is between the early adopters and early majority. Each crack indicates potential differences in the decision-making criteria regarding innovations. The chasm indicates a major gap in the thought process—early adopters versus early majority—that in turn typically creates a major obstacle in the marketing of high-technology products. We draw on this idea and develop our hypotheses related to migration based on a consumer's current generation (see Brown and Venkatesh 2003). Generally, innovators are technology enthusiasts who appreciate a technology for its own sake regardless of its specific functionalities. Early adopters are visionaries who are less interested in the value from the technology itself; rather, they are interested in the benefits of it to match a strategic opportunity or goal. Innovators and early adopters tend to be risk seeking because they can also typically, due to their affluence, bear the financial consequences of a failed technology. Innovators, in particular, and early adopters, to some extent, are trend setters who, through their adoption and opinion leadership, drive the rest of the market. The early majority are pragmatists who prefer to make incremental, measurable, and predictable progress. The late majority are conservatives who are against discontinuous innovations, believe far more in very gradual progress, and look for extensive endorsement from various sources, including actual market success. Finally, laggards are skeptics who do not participate in the high-technology marketplace (Moore 1999). In general, as the adopter continuum moves from innovators to laggards, users are less likely to adopt "technology

for the sake of technology" and become increasingly practical, conservative, and resistant to change. The early majority, late majority, and laggards tend to be progressively more risk averse.

The categories of adopters provide us grounding in the rich literature on adoption and diffusion to conceptualize categories of potential migrators; we also consider work on cross-generation effects at the macro level. The macrolevel literature suggests two types of migration—*leapfrogging* and *incremental* (e.g., Danaher et al. 2001). We extend this to suggest that there is a third category—namely, *transformational*. Our definition of the *incremental* migration situation is consistent with the macro diffusion literature. Consumers facing such a situation are those using the latest platform generation—i.e., generation of the platform that is closest to the new generation. However, users of older generations could be using one of many previous generations. These users could experience a major paradigm shift and a challenging learning curve should they decide to migrate to the newest generation. We refer to such a migration situation as *transformational*. In contrast, users of relatively newer generations do *not* face a *paradigm shift* and/or deal with dramatically new *types* of services when they migrate, but they do have to skip over some generations to migrate to the newest platform generation. We refer to such a migration situation as *leapfrogging*. We expect that the predictors identified in the MoMnUP will exert different effects on migration intention depending on the migration situation, i.e., extent of change, outlined above.

2.4.1. Moderating Effects on Technology Perceptions. Users in an incremental migration situation have kept up with the platform to date, thus putting them at the bleeding edge. They are, in all likelihood, innovators who adopt technology for the sake of technology, enjoy its use, and will be less concerned about the practical utility of the technology. Such consumers are also likely to be indifferent to risk due to higher affluence. At the other extreme are the users who have an older or even the oldest available platform—i.e., transformational migration situation. They have likely stayed with older platforms in spite of the availability of newer platforms due to skepticism, pragmatism, risk aversion, and/or financial constraints. The consumers in the leapfrogging situation typically are somewhere in between in their desire for pragmatism, level of skepticism, extent of risk aversion, and affluence.

Usefulness and ease of use tie directly to the practical utility and effort required. Together, they represent a cost–benefit assessment that relates to pragmatism. Like usefulness and ease of use, monetary value perceptions also relate to pragmatism. In addition, monetary value assessments relate to affluence and risk aversion. These drivers related to pragmatism can thus be expected to be most important to consumers in the transformational migration situation and become progressively less important in leapfrogging and incremental migration situations. Enjoyment, in contrast, is related closely to adopting technology for the sake of the technology. Compatibility is an issue related to one's lifestyle, which is a matter of intrinsic choice. A change in the platform presents an opportunity to change one's lifestyle due to the potential new services. Whereas those in an incremental migration situation will embrace such an opportunity, those in a transformational migration situation will not only face the potential for drastic changes but also be reluctant to embrace such changes due to their focus on pragmatism and maintaining status quo. These two drivers can be expected to be most important to consumers in the incremental migration situation and become progressively less important in leapfrogging and incremental situations. Therefore, we hypothesize the following:

Hypothesis 2A (H2A). *Generation will moderate the effect of usefulness on a consumer's platform migration intention such that the effect will be strongest in the transformational migration situation, weaker in the leapfrogging migration situation, and weakest in the incremental migration situation.*

Hypothesis 2B (H2B). *Generation will moderate the effect of ease of use on a consumer's platform migration intention such that the effect will be strongest in the transformational migration situation, weaker in the leapfrogging migration situation, and weakest in the incremental migration situation.*

Hypothesis 2C (H2C). *Generation will moderate the effect of monetary value on a consumer's platform migration intention such that the effect will be strongest in the transformational migration situation, weaker in the leapfrogging migration situation, and weakest in the incremental migration situation.*

Hypothesis 2D (H2D). *Generation will moderate the effect of enjoyment on a consumer's platform migration intention such that the effect will be strongest in the incremental migration situation, weaker in the leapfrogging migration situation, and weakest in the incremental migration situation.*

Hypothesis 2E (H2E). *Generation will moderate the effect of compatibility on a consumer's platform migration intention such that the effect will be strongest in the incremental migration situation, weaker in the leapfrogging migration situation, and weakest in the transformational migration situation.*

The superiority of services, although related to usefulness, is distinct in that the superiority here relates

to services that may be completely absent in the current generation of a platform. Consumers who are visionaries will embrace this potential because it creates an opportunity for them to innovate in their activities. The visionaries, as discussed earlier, are those in the incremental migration situation, and the superiority of services will be most important to those in that situation and become progressively less important in leapfrogging and transformational situations. The moderation of the effect of superiority of services on migration intention by generation can also be argued from a consumer expertise perspective. Expertise is a consumer's ability to perform product-related tasks successfully that requires product-related cognitive structures and processes. In general, product experiences positively influence consumer expertise (Alba and Hutchison 1987). When a new product is introduced, consumers with greater expertise, based on product experience, tend to have a better understanding of the product and evaluate it more accurately (Alba and Hutchison 1987). This moderating role of consumer expertise in innovation evaluation and adoption has been supported in prior work (e.g., Cowley and Mitchell 2003, Moreau et al. 2001). In our context, users in the incremental migration situation can be regarded as expert users because they possess the most extensive usage experience with the latest platform generation and thus have a better understanding of the variety and performance improvements of the new platform generation. Therefore, we hypothesize the following:

Hypothesis 2F (H2F). *Generation will moderate the effect of superiority of services on a consumer's platform migration intention such that the effect will be strongest in the incremental migration situation, weaker in the leapfrogging migration situation, and weakest in the transformational migration situation.*

2.4.2. Moderating Effects on External Influences. External influences are exerted by friends, family, and secondary sources, such as mass media (Brown and Venkatesh 2005). Also, image has been related to social or external influences (Brown and Venkatesh 2005, Venkatesh and Davis 2000). As discussed earlier, users of later generations of technologies are more innovative and are expected to seek new technologies for the sake of the having the newest technologies, being at the cutting edge, and getting the status gains that come with such a lead-user position (e.g., Venkatesh and Brown 2001). They are less susceptible to social influence and more motivated by the enhanced image and potential power, expert and referent, that will be conferred upon them, and play an opinion leadership role by being a lead-user. Image enhancement and status gains relate to trend setting that comes from early migration. In contrast, as noted earlier, consumers of earlier generations are conservative and employ a "wait-and-see" attitude. They will rely on friends and family to validate a new platform and guide them in the decision-making process. They are also less innovative and more risk averse, thus seeking external validation and advice from secondary sources, such as mass media. Consumers in the incremental migration situation are innovative and will, therefore, be less susceptible to the influence of others. This effect will become progressively stronger in leapfrogging and transformational migration situations. In contrast, the incremental migration situation comprises the group that will value the image enhancement that comes from early migration, and the emphasis on such value will decline among the more pragmatic consumers who populate the leapfrogging and transformational migration situations. Therefore, we hypothesize the following:

Hypothesis 3A (H3A). *Generation will moderate the effect of friends and family influence on a consumer's platform migration intention such that the effect will be strongest in the transformational migration situation, weaker in the leapfrogging migration situation, and weakest in the incremental migration situation.*

Hypothesis 3B (H3B). *Generation will moderate the effect of media influence on a consumer's platform migration intention such that the effect will be strongest in the transformational migration situation, weaker in the leapfrogging migration situation, and weakest in the incremental migration situation.*

Hypothesis 3C (H3C). *Generation will moderate the effect of image on a consumer's platform migration intention such that the effect will be strongest in the incremental migration situation, weaker in the leapfrogging migration situation, and weakest in the transformational migration situation.*

2.4.3. Moderating Effects on Complementarities. We propose that technology generation moderates the effects of the three complementarities on migration intention. Consumer adoption of any innovation involves a learning process in which prior experiences and the derived expertise play a role (Alba and Hutchison 1987, Moreau et al. 2001). Alba and Hutchinson (1987) proposed that consumers' product-related experiences, such as advertisement exposure, information search, and product use, influence their expertise, defined as the ability to perform product-related tasks successfully, such as evaluating product innovation with better cognitive structures (e.g., beliefs) and more effective processes (e.g., decision rules about beliefs). Particularly, compared to novice consumers, expert consumers will have more and better knowledge about the relationships among technologies in the ecosystem because expert consumers

have developed their knowledge structures about the technology hierarchy from their rich(er) use experiences with and information exposure to the more advanced (thus, a more complex system of) technologies and services (Alba and Hutchison 1987).

Different levels of expertise imply different consumer learning processes regarding innovations in the new generation of technology hierarchy, such as new services (e.g., experience sharing by real-time video), new applications (e.g., MMS), a new software platform (e.g., Symbian OS version 9.5 for 3G), and a new hardware platform (e.g., mobile devices supporting video cameras and the 3G broadband network). Because expert consumers tend to have knowledge structures that better match the layered system of ICTs, they will be better able to understand the associations among the layers and use complementarities across the ecosystem when evaluating the new platform generation. In contrast, novice consumers, due to their limitations in understanding of the entire technology hierarchy and the importance of complementarities, tend to bias their attention to the layers that are most easy for them to see and understand, i.e., complementarities between services and applications. Thus, as expertise decreases, the relative importance of complementarities at lower layers will also decrease.

The above logic has been supported in work on knowledge transfer by analogical learning (e.g., Gregan-Paxton and John 1997, Moreau et al. 2001). Research suggests that when evaluating innovations, existing knowledge (i.e., expertise) plays a key role in the creation of new knowledge (e.g., judgment about the new technology generation). Particularly, learning by analogy refers to the process of transferring knowledge from a familiar domain (e.g., 2.5G) to a novel domain (e.g., 3G) as a function of the structural correspondence between the two domains (e.g., 2.5G offers picture sharing services supported by photo cameras on mobile devices, which corresponds to 3G video sharing services supported by video cameras; Gentner 1989). It has been argued and empirically supported that expert consumers, equipped with the ability to identify more correspondences between the old and the new, can map and transfer knowledge about both attributes (e.g., technology layers) and relationships among them (i.e., complementarities) from the base to the target. In contrast, novice consumers can only map and transfer knowledge about a limited set of attributes (Gregan-Paxton and John 1997, Moreau et al. 2001). This suggests that expert consumers will consider a greater range of complementarities than novice consumers will.

In the context of migrating to a new ICT platform generation, users of later generations are likely to be more expert due to experiences with a richer set of advanced ICT services than users of earlier generations. They are thus more likely to be knowledgeable about different layers in the technology hierarchy and sensitive to complementarities between various pairs of layers. This is because the seamless use of the newest services usually demands complementary innovations across different layers of the hierarchy. For instance, when faced with a decision regarding whether or not to migrate to the 3G, users of the 2.5G may already have had experiences with advanced services, such as enhanced messaging service (EMS),[5] ringtone downloads, mobile games, and e-mail. In contrast, users of earlier generations would have only had experiences with primitive services, such as text-based Web browsing, SMS, or even only voice phone calls. Thus, 2.5G users are likely to know from their past experiences that the seamless experience of picture sharing service would depend on the availability of an EMS application, which in turn may require a new version of an operating system that would be supported only in advanced phone models with powerful cameras and color screens. Further, they are likely to recognize the need for synergies across various layers for the newest services to work well. When faced with a decision regarding migration to 3G, such users will only migrate if they see enough complementarities in the hierarchy related to 3G—from services to applications to software platform to hardware platform. In contrast, users who are still using older platform generations may mainly process new features in each layer in a piecemeal and ad hoc manner without understanding the importance of all the complementarities. They are most likely to be sensitive to the most visible complementarity—between the new application and services. For instance, when they see the demo of 3G video phone calls, they may *not* associate this new service with the underlying new application of MMS that in turn would only function well on a new operating system that in turn may only function well on new mobile phone models. Therefore, as we move from the upper layers, such as services and applications, to the lower layers, such as the platforms, consumers with less expertise who will likely be users of earlier platform generations (i.e., transformational and leapfrogging migration situations) will only minimally value complementarities in their migration decisions. Specifically, consumers at the cutting edge (i.e., incremental migration situation) will be sensitive to all the complementarities, whereas the less tech-savvy consumer who will be using older platform generations (i.e., leapfrogging

[5] With EMS, consumers can take pictures with the camera on their mobile devices and then send the pictures in real time to receivers' mobile devices. With MMS based on the 3G, consumers can take and send videos to the receivers.

and transformational situations) will progressively focus only on the more directly visible complementarities (i.e., applications–services), and even then to a lesser extent than users of newer platform generations. Therefore, we hypothesize the following:

Hypothesis 4A (H4A). *Technology generation will moderate the impact of complementarities between the hardware platform and software platform on migration intention such that the effect will be strongest in the incremental migration situation, weaker in the leapfrogging migration situation, and weakest in the transformational migration situation.*

Hypothesis 4B (H4B). *Technology generation will moderate the impact of complementarities between software platform and applications on migration intention such that the effect will be strongest in the incremental migration situation, weaker in the leapfrogging migration situation, and weakest in the transformational migration situation.*

Hypothesis 4C (H4C). *Technology generation will moderate the impact of complementarities between applications and services on migration intention such that the effect will be strongest in the incremental migration situation, weaker in the leapfrogging migration situation, and weakest in the transformational migration situation.*

2.5. Control Variables

A variety of individual characteristics influence consumer decision making, especially related to technologies (e.g., Brown and Venkatesh 2005, Donthu and Gilliland 1996). We include demographics (*age*, *gender*, and *income*) and personal dispositions (*risk aversion* and *personal innovativeness with information technology* (*PIIT*)) as control variables. Particularly, PIIT[6] is "the willingness of an individual to try out any new information technology" (Agarwal and Prasad 1998, p. 206), and risk aversion is defined as an individual's propensity and tolerance for risk (Bauer 1960, Munichor et al. 2006), both likely to influence migration to innovations with an unknown and uncertain future. For instance, people with higher level of innovativeness may embrace new generations, whereas risk-averse consumers may prefer to wait. Finally, we control consumers' perceptions of their *current service operators' performance*.

2.6. Behavioral Criterion

To add criterion validity to the MoMnUP, we will examine both *migration behavior* and *use of the new platform generation* as dependent variables. The intention–behavior relationship is well established in psychology and information systems research, including work on consumer adoption (see Venkatesh and Brown 2001, Venkatesh et al. 2003). Although a vast body of work exists on this relationship, whenever a new behavior is studied, it should be related to intention. In the context of consumer platform migration, although there may be some roadblocks to consumers following up on their expressed intentions (see Venkatesh et al. 2006), there are no social desirability or other biases that would preclude behavioral performance. Therefore, we hypothesize the following:

Hypothesis 5A (H5A). *Migration intention will positively influence migration to the new platform.*

Hypothesis 5B (H5B). *Migration intention will positively influence the use of the new platform.*

3. Method

In this section, we describe the setting, participants, measures, and data collection procedure.

3.1. Research Setting: 3G Introduction

We studied consumer perceptions and migration intention to a new ICT platform—i.e., 3G—in Hong Kong. The 3G broadband data capabilities and the new devices with improved features served as the hardware platforms. New operating systems (e.g., Symbian 9.5 and Windows Mobile 5.0) together with development tools (e.g., J2ME) served as the software platforms. New applications available included MMS and a location suite that in turn enabled services not available on 2G and 2.5G platforms, e.g., experience sharing with MMS and real-time navigation guides (UMTS Forum 2006). The setting also offered a way to study consumers' migration to a new platform generation when multiple old generations are present, i.e., 2G (voice), 2G (voice and data), and 2.5G. We mapped the three types of platform migration situations from our study setting to the three conceptual categories of migration as follows:

1. 2G (voice): Voice communication is the sole application for this group of users. Despite the proliferation of data services, such as SMS, EMS, and ringtone downloads, these services are not used by this group of users. To migrate to the 3G directly represents a *transformational* decision to them.

2. 2G (voice and data): This group of users uses both voice communication and SMS, which is a simple text-messaging data service. Unlike the previous group, the 3G platform is not transformational because of their prior experience with SMS. To users in this group, the decision is whether to *leapfrog* 2.5G and adopt 3G directly.

3. 2.5G (data): Users in this group are familiar with novel MDS, such as EMS, game downloads, and mobile Internet. Migrating to 3G will offer this group better quality and higher bandwidth and access to

[6] Although Agarwal and Prasad (1998) used the term IT, we refer to ICT as mentioned earlier in this paper.

new applications and some new services. Their decision to adopt 3G represents an *incremental* migration.

3.2. Measurement

Online Appendix 1 (provided in the e-companion)[7] lists our scales. Most scales were adapted from prior research and modified to fit our context. Three formative items, adapted from Venkatesh et al. (2003), were used to measure *migration intention* given that our items focused on different aspects related to migration (see Petter et al. 2007). *Migration* to the 3G and *use* of 3G services were assessed using self-reports of behavior using items adapted from prior research. The scales for *usefulness, ease of use, enjoyment, compatibility, friends and family influence, media influence*, and *image* were adapted from Brown and Venkatesh (2005) and Venkatesh et al. (2003). The scale for *monetary value* was adapted from Dodds et al. (1991). The scale for *service operator performance* was adapted from Cronin et al. (2000). The scales for the two personal disposition constructs—*risk aversion* and *PIIT*—were adapted from Donthu and Gilliland (1996) and Agarwal and Prasad (1998), respectively. The measurement of the manipulation check variable—*perceived radicalness* of the new platform, defined as degree to which a consumer believes novel technological content is embodied in the new platform generation when compared to existing generations (Dewar and Dutton 1986)—was adapted from Gatignon et al. (2002).

We developed new multi-item scales for *superiority of services* and each of the three *complementarities* based on the definition of constructs. Superior services improve performance in a cost-effective way (McGrath 1995, Norton and Bass 1987, Sawhney 1998) and our three-item scale captured these aspects. Our items for complementarities focused on the synergies across the layers in the hierarchy, and captured elements of variety, smoothness, effectiveness, and efficiency. To arrive at the final scales, we used the various steps described in DeVellis (2003). Based on the definition and items, the scales for superiority of services and each of the three complementarities were treated as having formative indicators (see Petter et al. 2007).

When 3G was introduced in Hong Kong, both the 2G and 2.5G platforms also coexisted. Also, among 2G users, some were using only voice services without any data applications. To distinguish 2G voice users, 2G data users, and 2.5G users, a representative portfolio of mobile data services currently available in Hong Kong were selected. Those who never used any data services were classified as 2G voice users, those who had only used SMS were classified as 2G data users, and those who also used other data services, such as MMS, were classified as 2.5G users. Further, we reconciled the services with the phone model that the consumer was using to ensure accurate categorization of consumers. Finally, we explicitly asked a question on the survey about the respondent's platform generation. This approach minimizes the risk of erroneous classification (e.g., Lee et al. 2002). These different measures were highly correlated (>0.80). In the event of a discrepancy, we used the services used as the decider because it was the most accurate. After categorization, we had 336 2G voice users, 820 2G data users, and 3,256 2.5G users.

Given that Chinese (Cantonese) is the official language in Hong Kong, the items were translated into Cantonese by someone unfamiliar with the research and its objectives, and the back-translation to English was done by a different translator. Any discrepancies were discussed and resolved. We conducted a pretest among approximately 100 consumers who had varying levels of experience with mobile services. Minor wording changes were made based on the feedback received from the pretest participants. A pilot study was conducted with a similar sample, and the reliability and validity of the scales were supported.

3.3. Participants and Data Collection

We collected data using two surveys, administered before and after the introduction of 3G in Hong Kong. The first survey was conducted one month before the introduction of 3G and focused on consumer reactions, including intention. The questionnaire was administered via a nonprofit Hong Kong e-government portal, with free membership to any permanent resident of Hong Kong. An e-mail with a link to the questionnaire was sent to members of the portal to solicit participation. To help respondents understand the new ICT platform (i.e., 3G) and its implications, flash demonstrations of 3G mobile services, such as the videophone service, video clip downloads, and MMS, were presented to respondents prior to filling out the questionnaire. The online survey was administered for one month and generated 5,074 responses. Data were first cleaned by removing incomplete responses and "suspicious" responses (e.g., extremely fast completion times, responses to all questions were 7s). Next, invalid observations were deleted when there were contradictory answers to the reverse-coded item for perceived radicalness. Thus, the quality of the data was significantly improved (see Ilieva et al. 2002). After these steps, we had 4,412 usable responses. As noted earlier, 336 were 2G voice only users, 820 were 2G voice and data users, and 3,256 were 2.5G users. The second wave of surveys was administered when 3G was fully introduced by all licensed service operators in Hong Kong

[7] An electronic companion to this paper is available as part of the online version that can be found at http://mansci.journal.informs.org/.

and focused primarily on behavior—i.e., migration and use of 3G—in the first six months. In the second wave, 2,333 of the initial 4,412 participants provided usable responses. The demographic profiles of the respondents in the first and second waves were similar (see Online Appendix 2).

4. Results

We analyzed our data using partial least squares (PLS) because it allows for the use of formative indicators. The specific software used was Smart-PLS. We first present the results from our preliminary analysis (i.e., measurement model) and then the results of our hypothesis testing (i.e., structural models).

4.1. Preliminary Analysis

The loadings of all constructs modeled with reflective indicators were above 0.70 and the cross-loadings were below 0.37, suggesting discriminant validity (Fornell and Bookstein 1982). We used the Harman's test to test for common method bias and did not find support for a method factor. Further, given that we collected behavioral data several months after the measurement of consumer reactions, including intention, and relate intention to behavior, this concern is further alleviated. For the constructs modeled with formative indicators, the weights were as follows: migration intention, 0.29, 0.34, 0.35; superiority of services, 0.24, 0.29, 0.33; complementarities (hardware and software platforms), 0.20, 0.28, 0.36; complementarities (software platform and applications), 0.30, 0.25, 0.31; and complementarities (applications and services), 0.23, 0.29, 0.34. Internal consistency reliabilities (ICRs) were computed for scales with reflective indicators and were found to be greater than 0.80. The descriptive statistics, ICRs, average variance extracted (AVE), and correlations are shown in Table 1.

We also examined the perceived radicalness of the new platform as a manipulation check and found that the different groups varied significantly in their perceptions of radicalness: incremental group, mean = 3.30, SD = 0.33; leapfrogging group, mean = 4.60, SD = 0.35; and transformational group, mean = 6.12, SD = 0.21. All pairwise differences were statistically significant.

4.2. Hypothesis Testing

We used the entire sample to test the MoMnUP. We examined the follow-up behavioral data to examine the relationship between (a) intention and migration and (b) intention and use of 3G services. We mean centered variables that were used in interaction terms, which were created at the indicator level, to minimize multicollinearity (Aiken and West 1991). All variance inflation factors were below 6, thus alleviating concerns about multicollinearity. The results of the structural model tests are shown in Tables 2 and 3. We

Table 1 Reliability, Descriptive Statistics, and Correlations

	ICR	Mean	SD	MIGINT	Gdr	Age	Inc	RA	PIIT	SPP	U	EOU	MV	ENJ	COMPAT	ESS	FnFI	MI	IMAGE	HPnSP	SPnA	AnS
MIGINT	NA	4.44	1.29	0.82																		
Gdr (1: men)	NA	0.47	0.50	0.27	NA																	
Age	NA	27.35	7.77	0.27	0.05	NA																
Inc	NA	8.444	3.542	0.20	0.04	0.33	NA															
RA	0.84	5.02	1.37	−0.21	0.25	0.05	0.05	0.80														
PIIT	0.83	4.51	1.38	0.26	0.27	0.04	0.07	−0.20	0.81													
SPP	0.80	4.80	1.44	−0.15	−0.17	0.13	0.08	0.08	0.13	0.84												
U	0.91	4.30	1.27	0.28	0.28	0.25	0.20	−0.21	0.20	0.13	0.88											
EOU	0.92	4.97	1.24	0.30	0.25	0.22	0.21	−0.21	0.25	0.14	0.23	0.86										
MV	0.79	4.31	1.08	0.29	0.20	0.20	0.23	−0.20	0.18	0.02	0.27	0.22	0.80									
ENJ	0.88	3.98	1.22	0.19	0.19	−0.18	0.13	−0.22	0.33	0.03	0.13	0.22	0.11	0.82								
COMPAT	0.80	5.01	1.59	0.17	0.14	−0.20	0.11	0.08	0.15	0.05	0.27	0.18	0.18	0.07	0.80							
SS	0.88	5.31	1.09	0.30	0.22	0.08	0.07	−0.22	0.21	0.06	0.20	0.30	−0.22	0.13	0.07	0.82						
FnFI	0.90	4.11	1.40	0.30	0.30	0.17	0.15	−0.23	−0.20	0.09	0.28	0.30	0.23	−0.15	0.11	0.25	0.81					
MI	0.85	4.19	1.20	−0.24	0.25	0.07	0.15	0.12	0.20	0.11	0.27	0.27	0.22	−0.13	0.13	−0.25	−0.25	0.77				
IMAGE	0.81	3.55	1.23	0.28	0.19	−0.18	0.15	−0.13	0.27	0.08	0.09	0.12	0.09	0.09	0.08	0.07	−0.15	−0.13	0.73			
HPnSP	NA	3.44	1.45	0.30	0.23	−0.16	0.11	−0.14	0.23	0.11	0.11	0.14	0.07	0.20	0.17	0.13	−0.13	−0.07	0.08	0.75		
SPnA	NA	4.12	1.39	0.31	0.24	−0.13	0.14	−0.11	0.25	0.11	0.14	0.11	0.11	0.17	0.19	−0.14	−0.16	−0.15	0.13	0.22	0.73	
AnS	NA	4.50	1.55	0.39	0.20	−0.13	0.16	0.08	0.29	0.13	0.15	0.16	0.14	0.22	0.24	−0.17	0.08	−0.17	0.15	0.17	0.24	0.74

Notes. MIGINT, Migration intention; Gdr, gender (1: women); Inc, monthly income in HKD; RA, risk aversion; PIIT, personal innovativeness with IT; SPP, service provider performance; U, usefulness; EOU, ease of use; MV, monetary value; ENJ, enjoyment; COMPAT, compatibility; SS, superiority of services; FnFI, family and 'friends' influence; MI, media influence; HPnSP, complementarities, hardware platform and software platform; SPnA, complementarities, software platform and applications; AnS, complementarities, applications and services. Diagonal elements are AVEs. Off-diagonal elements are correlations. Only correlations <0.10 were nonsignificant; others were significant at least at $p < 0.05$.

Table 2 Predicting Migration Intention

	Model 1	Model 2	Model 3	Model 4a	Model 4b	Model 4c
R^2	0.08	0.28	0.38	0.60	0.47	0.55
ΔR^2	0.08	0.20	0.10	0.22	0.09	0.17
Gender (1: men)	0.13***	0.02	0.02	0.01	0.01	0.02
Age	−0.12**	0.02	0.02	0.02	0.02	0.02
Income	0.04	0.03	0.03	0.02	0.02	0.03
Risk aversion	−0.11**	−0.10*	−0.10*	−0.04	−0.04	−0.10*
Personal innovativeness with IT	0.17***	0.14**	0.14**	0.07	0.07	0.14**
Current service provider performance	−0.08	−0.09	−0.03	−0.02	−0.02	−0.03
Usefulness (U)		0.16***	0.14**	0.04	0.04	0.15***
Ease of use (EOU)		0.13*	0.12*	0.03	0.03	0.12*
Monetary value (MV)		0.01	0.01	0.00	0.00	0.01
Enjoyment (ENJ)		0.10*	0.07	0.02	0.02	0.08
Compatibility (COMPAT)		0.10*	0.05	0.02	0.02	0.06
Superiority of services (SS)		0.23***	0.15***	0.12*	0.12*	0.17***
Friends and family influence (FnFI)		0.03	0.05	0.05	0.05	0.05
Media influence (MI)		0.04	0.00	0.00	0.00	0.00
Image (IMAGE)		0.15***	0.12*	0.07	0.07	0.13**
Complementarity (h/w and s/w platfs.)—COMP-HPnSP			0.16***	0.07	0.14**	0.10*
Complementarity (s/w platf. and applns.)—COMP-SPnA			0.19***	0.09	0.16***	0.10*
Complementarity (applns. and services)—COMP-AnS			0.25***	0.14*	0.16***	0.12*
Generation (0: Increm.; 1: Leapfrog.; 2: Transform.)				0.03	0.03	
U × Generation				0.16***	0.16***	
EOU × Generation				0.13**	0.15***	
MV × Generation				0.05	0.05	
ENJ × Generation				−0.15***	−0.15***	
COMPAT × Generation				0.12***	0.16***	
SS × Generation				0.15***	0.16***	
FnFI × Generation				0.11*	0.14*	
MI × Generation				−0.12*	−0.13*	
IMAGE × Generation				−0.10*	−0.13*	
COMP-HPnSP × Generation				−0.21***		−0.28***
COMP-SPnA × Generation				−0.22***		−0.30***
COMP-AnS × Generation				−0.24***		−0.33***

Note. h/w, Hardware; s/w, software.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

first discuss the results in Table 2. Model 1 shows the results from the inclusion of only the control variables as predictors and explains 8% of the variance in migration intention. Model 2 shows the results when the main effects for technology perceptions and external influences were added, and explains 28% of the variance in migration intention. Model 3 shows the results with the main effects of various complementarities included and explains 38% of the variance in migration intention. Finally, model 4a includes all interaction terms and explains 60% of the variance in migration intention. To demonstrate the explanatory power of interaction terms between complementarities and technology generation, we compared the full model (model 4a) with two nested models (models 4b and 4c) and found model 4a to explain the most variance. Interestingly, model 4c, which includes only the interactions related to the complementarities, explains as much as 55% of the variance in migration intention. Table 3 shows the results related to model 4a broken down by different generation groups separately—i.e., incremental, leapfrogging, and transformational—thus allowing a clear intergroup comparison.[8] The pattern of results is identical across the two tables.

Table 2, model 2 shows that all technology perceptions, except monetary value, were significant in predicting migration intention, thus largely supporting what is known in prior research. Also, as shown in Table 2, model 2, image was the only external influence that was significant, thus partially supporting what is known regarding the role of external influences. From Table 2, model 3, we see that all three complementarities had a significant direct effect, thus supporting H1A–H1C. As we examined support for the moderation effects proposed in H2A–H4C, Table 2, model 4 shows that most of interaction terms

[8] Before the intergroup comparison, we established measurement invariance at the factor pattern level (Vandenberg and Lance 2000) for the nonformative scales by LISREL multisample test (Joreskog and Sorbom 1996). Goodness of fit indices (standardized root mean square residual, root mean square error of approximation, and nonnormed fit index) indicated the invariance in factor pattern across the three generation groups (Hu and Bentler 1998).

Table 3 Predicting Migration Intention: Comparison Across Migration Situations

	Migration situations		
	Group 1: Incremental	Group 2: Leapfrogging	Group 3: Transformational
R^2	0.51	0.41	0.40
Gender	0.01	0.02	0.02
Age	0.02	0.02	0.02
Income	0.02	0.02	0.01
Risk aversion	0.04	−0.10*	−0.13**
Personal innovativeness with IT	0.20***	0.13**	0.08
Current service provider performance	0.10*	−0.07	−0.10*
Usefulness	0.10*	0.16***	0.21***
Ease of use	0.02	0.10*	0.17***
Monetary value	0.03	0.10*	0.13***
Enjoyment	0.12**	0.07	0.03
Compatibility	0.13**	0.05	0.03
Superiority of services	0.19***	0.14**	0.06
Friends and family influence	0.02	0.11*	0.18***
Media influence	0.10*	−0.14**	−0.19***
Image	0.15***	0.03	0.01
Complementarity (h/w and s/w platforms)	0.26***	0.09	0.03
Complementarity (s/w platform and applns.)	0.28***	0.23***	0.10*
Complementarity (applns. and services)	0.30***	0.26***	0.24***

Note. h/w, Hardware; s/w, software.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

were indeed significant. However, to fully understand the differences across the various groups, we also examined the results shown in Table 3. We also conducted a Chow's test of beta differences to examine pairwise beta differences. Table 4 presents a summary of the pairwise comparisons and extent of support for the hypotheses. For the most part, H2A–H4C were supported. Most importantly, the pattern predicted with regard to the complementarities was fully supported.

In terms of predicting our behavioral criterion of migration and subsequent use of 3G services, we used the follow-up behavioral data from 2,333 respondents. We found that the intention to migration odds ratio was 1.75, thus suggesting that those with higher intent were more likely to migrate. Migration intention also related to use of the 3G—with a correlation of 0.51 ($p < 0.001$). These results support H5A and H5B and lend additional validity to the MoMnUP. Although due to space constraints we do not show the results here, we also directly tested the various predictions into use of 3G services and found a similar pattern of main and interaction effects to what was observed when migration intention was a dependent variable.

5. Discussion

We proposed and tested a model of consumer migration to the newest generation of an ICT platform. The model, with constructs primarily drawn from prior research on adoption, received modest support and explained 28% of the variance in migration intention, an increase of 20% over the model with control variables only. The model that included the complementarities across the technology hierarchy explained 38% of the variance in migration intention. Finally, the model with the various interaction terms explained

Table 4 Summary of Moderation Effects: Pairwise Comparison of Beta Differences Across Migration Situations

Category	Construct	Incremental vs. leapfrogging[a]	Leapfrogging vs. transformational[a]	Comments
Technology perceptions	Usefulness	Leapfrogging	Transformational	H2A supported
	Ease of use	Leapfrogging	Transformational	H2B partially supported (ns in incremental)
	Monetary value	Leapfrogging	Transformational	H2C supported
	Enjoyment	Incremental	No difference	H2D supported
	Compatibility	Incremental	No difference	H2E partially supported (ns in leapfrogging and transformational)
	Superiority of services	Incremental	Leapfrogging	H2F supported
External influences	Friends and family influence	Leapfrogging	Transformational	H3A supported
	Media influence	Leapfrogging (stronger negative)	Transformational (stronger negative)	H3B partially supported (negative in leapfrogging and transformational)
	Image	Incremental	No difference	H3C supported
Complementarities	Hardware and software platforms	Incremental	No difference	H4A supported
	Software platform and applications	Incremental	Leapfrogging	H4B supported
	Applications and services	Incremental	Leapfrogging	H4C supported

Note. ns, Nonsignificant.
[a]The cells indicate the group for which the effect was stronger.

60% of the variance in migration intention. Consistent with our predictions, the type of migration situation—i.e., incremental, leapfrogging, or transformational—moderated the effects of technology perceptions, external influences, and complementarities on migration intention. Migration intention predicted migration to and use of the newest platform generation.

5.1. Theoretical Contributions and Implications

Our work contributes to research in different streams from which we draw. We study a new type of ICT-related behavior—i.e., consumer migration to the newest ICT platform generation—that is widely prevalent in today's ICT industry. The MoMnUP is integrative and includes constructs from prior work on adoption and consumer behavior, and extends the same by drawing from macrolevel research. Our major contribution is conceptualizing the technology hierarchy and complementarities at the micro—i.e., individual—level. We conceptualize three types of complementarities between layers in the technology hierarchy. Further, we find that these complementarities play a strong role in driving consumers' migration intentions to the newest platform generation. We extend prior consumer adoption research by modeling a moderating role for the extent of change from the current generation that a consumer is using, and identify three conceptual categories associated with migration decisions—i.e., transformational, leapfrogging, and incremental. A related contribution of our work is the development of scales for several constructs, particularly the different complementarities. In sum, our work helps understand the role of the ICT ecosystem in consumer adoption and use of ICT platforms.

Our work goes beyond traditional technology adoption research in a few important ways. By conceptualizing the extent of change as an important moderator of key relationships, the current ICT artifact is given a central role in the model. As pointed out by Orlikowski and Iacono (2001), one of the five premises for theorizing about ICT artifacts is that "*artifacts undergo various transitions over time . . . while coexisting and coevolving with multiple generations of the same or new technologies at various points in time*" (p. 131; emphasis added). As we noted earlier, technology generation has been studied in innovation diffusion research at a macro level, i.e., market or product level (e.g., Danaher et al. 2001, Norton and Bass 1987). By bringing the idea of extent of change to understand consumer migration decisions, we make a contribution to knowledge in this area. Specifically, the degree of change in each new generation over the old has not been modeled previously at the individual consumer level. The MoMnUP thus complements macrolevel work on innovation diffusion and extends microlevel work on consumer adoption and use of technologies.

Platform strategy is the foundation for ICT product development (McGrath 1995). Although there are a number of studies of ICT platforms (e.g., Gawer and Cusumano 2002, Sawhney 1998), much of that work has focused on issues related to the supply side, e.g., the platform leadership strategy, with a focus on how to achieve optimal complementarities by coordinating innovation efforts of other companies that produce complementary technologies. Consumers' reactions to platform innovations have been less studied. Our work studies the impacts from the demand side on the success of platform leadership strategy—i.e., how complementarities determine consumers' migration to a new platform generation—because the realization of the strategic value of ICT platform leadership, such as seizing market share from competitors, depends on users' embracing the new generation. Thus, our work complements and sheds new light on platform leadership strategy in particular and strategic management of ICTs in general.

The negative effect of media influence in the incremental and leapfrogging situations is both surprising and interesting. We speculate that this is because of 2G users' defensive processing of external information (e.g., news reports, advertisements) about 3G. Such defensive processing is likely due to the failure of 2G WAP in living up to projections. When product performance fails to meet advertisers' claims, consumers' distrust of the advertiser will be evoked and may even generalize to other media, authority, and future attempts of persuasion (Pollay 1986). This type of distrust could create a negative bias in consumers' judgments such that they overgeneralize their distrust to situations where it is not warranted. Even superior products and those introduced by other, different organizations are vulnerable to such a defensive bias (Chaiken et al. 1996, Darke and Ritchie 2007). It is quite possible that this defensive information processing played a role in the case of 3G migration. MDS, based on 2G WAP, had been widely advocated by the media as a comparable mobile version of the wired Internet. However, what consumers got from the 2G WAP was an experience that was termed "wait-and-pay." These problems perhaps evoked consumers' skepticism about 3G. This bias may be particularly strong for voice and SMS users because, unlike 2.5G users, 2G users still stayed on the 2G platform, and the failure of WAP could have more easily triggered defensive information processing. In contrast, 2.5G users may already have had experiences with the performance and functionality improvement of the much-improved 2.5G platform, thus having little or no defensive bias. This negative effect of media influence further supports the importance of technology

generation as a moderator and highlights the importance of the current platform generation as a critical moderator at the individual level.

Our work points to a few important future research directions. The support for the role of the technology hierarchy at the microlevel calls for further work on the hierarchy. For instance, it is possible that there are additional entities (e.g., network) that could be included in the hierarchy. Consequent to expanding the technology hierarchy, there will be a need to examine whether there are additional complementarities that influence consumer decisions. Also, there could be perceived complementarities that break the chain described in Figure 1 that merit study. As we pointed out, our work complements macrolevel research on platform leadership. Future research should investigate this phenomenon in a multilevel fashion with platform leadership strategies at the higher level and consumer decision-making constructs at the lower level. Future research should also study other outcomes beyond migration and use. For instance, whereas we controlled for current service provider performance, future research may examine service performance as a dependent variable. Another future research direction emerges from a limitation of our work—i.e., Hong Kong comprises one of the most technology-savvy societies in the world and thus, the generalizability of our findings to lesser technology-savvy countries, including the United States, should be examined. Finally, a natural extension to employee adoption research would be to examine if complementarities play a role in the decision-making process. Like we did in the consumer context, the role of compatibility and complementarity should be investigated together in employee adoption settings.

5.2. Practical Implications

Whereas Rogers (1995) and Moore (1999) provided an ex post description of adopter categories, we believe technology generation offers an ex ante identification of consumer segments with strategic implications for ICT service innovations. We found evidence of differences in drivers of migration intention across these three consumer segments—i.e., transformational, leapfrogging, and incremental. ICT firms should design strategies tied to the factors that are most important to each category. For example, in the case of 3G migration, mobile service packages with advanced technology can be targeted at 2.5G users with a premium price, whereas ease of use and practical value of 3G should be emphasized when communicating with 2G data users.

The negative effect of media influence suggests that ICT firms should seek to actively manage the potential negative impact of old technology generations on the new one. When promoting a new generation of an ICT platform, ICT service providers need to take into account the negative biases created by the inferiority or even failure of previous generations, especially when there is a coexistence of multiple old generations. Users of older generations are more likely to distrust information about the superiority of a new platform due to their experiences with the inferior functionality of its predecessors, and media campaigns will only serve to fortify these negative views. Consequently, any media advertising would have a negative effect. Thus, caution is needed for decisions about marketing practices, especially advertising and other media forms.

Platform leadership has been studied from a perspective of strategic management of innovations (e.g., Gawer and Cusumano 2002). A particular focus has been how companies like Intel, Microsoft, Cisco, and NTT DoCoMo sustain their long-term competitive advantage through the successful introduction of new platforms—e.g., central processing units, Windows, Internet/Intranet technologies, and c-HTML plus specialized mobile devices. However, research and practice have largely neglected the distinction between incremental and transformation platform migration behaviors. Our paper shows that the majority of consumers do care about the radicalness of technological change resulting from platform migration. Thus, we suggest the importance of the strategic management of consumers' behavioral change triggered by service innovations. Particularly, communication or design strategies, such as education using analogy or metaphors, could facilitate consumers' learning about the advantages offered by the new platform and lessen the burden of trial and error when using new ICT services. Further, educating consumers about the various complementarities that appear to play a role in their decision making is crucial. It is important that consumers have a realistic assessment of the time lag that exists in ensuring sufficient complementarity in the ICT ecosystem.

6. Conclusions

We developed a model of consumers' migration and use of the newest ICT platform generation. Integrating research on platform strategy, technology adoption, and consumer behavior, we proposed three categories of factors that influence consumer's platform migration intention: technology perceptions, external influences, and complementarities. Complementarities between the hardware and software platforms, software platform and applications, and applications and services played a strong role. Further, the effect of these complementarities on migration intention varied depending on the extent of change between a consumer's current platform generation

and the newest generation. Overall, this suggests the need for the ICT industry to think carefully about how best to develop technologies in different layers and promote the same to different groups of users.

7. Electronic Companion

An electronic companion to this paper is available as part of the online version that can be found at http://mansci.journal.informs.org/.

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