Three Models of Technology Adoption: A Literature Review in Brief

An MIT AgeLab CareHive Research Note

September 2020

Introduction

The rise of personal computers in the 1980s spurred a research question that remains relevant to us today: what drives people to purchase, learn to use, and ultimately adopt an unfamiliar – and sometimes radically novel – technology? While the early personal computer was a powerful new tool with numerous uses, especially in workplace settings, its advancements in terms of size, efficiency, power, and cost along with the internet in the 1990s and 2000s would lead to an explosion of development of consumer electronics – laptop computers, smartphones, wearables, personal assistants, automated vehicles, and advanced appliances relying on internet connectivity and computing features. This proliferation of new technologies and their increasing influence over daily life has spurred enormous growth in research on technology adoption as a phenomenon. Today, a person's willingness – or lack thereof – to adopt new technologies may have a significant effect on his or her quality of life. And a developer's attention to relevant technology adoption factors within the relevant user population may mean the difference between a successful or failed product.

This research note will briefly examine the rise and development of models of technology adoption from the 1980s to the present decade. In doing so, we will observe how researchers have identified a ballooning number of generally relevant technology adoption factors. This growth in complexity may suggest the need to focus on particular subgroups or scenarios in order to provide an intelligible descriptive model. We will accordingly look at a technology adoption model that is specifically designed to consider older adults, and how such a model points toward research directions for similar subgroups, such as caregivers.

Methodology

This research note condenses prior comprehensive literature reviews on technology adoption conducted by Lee and Coughlin (2015), and Lee et al. (2018). Drawing from these papers, we will focus on three models of technology adoption that were published in 1989, 2003, and 2015.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) by Fred Davis (1989) is an early framework for describing technology adoption, with a specific focus on the adoption of technologies in the information sciences domain. Davis' model focuses primarily on the concepts of *perceived ease of use* and *perceived usefulness* of a technology by a prospective adopter. The interaction between a particular user and a technological system (such as through learning about the technology indirectly or encountering directly) generates perceptions of ease of use and usefulness. These perceptions inform the user's attitudes and intentions toward the use of the technology.

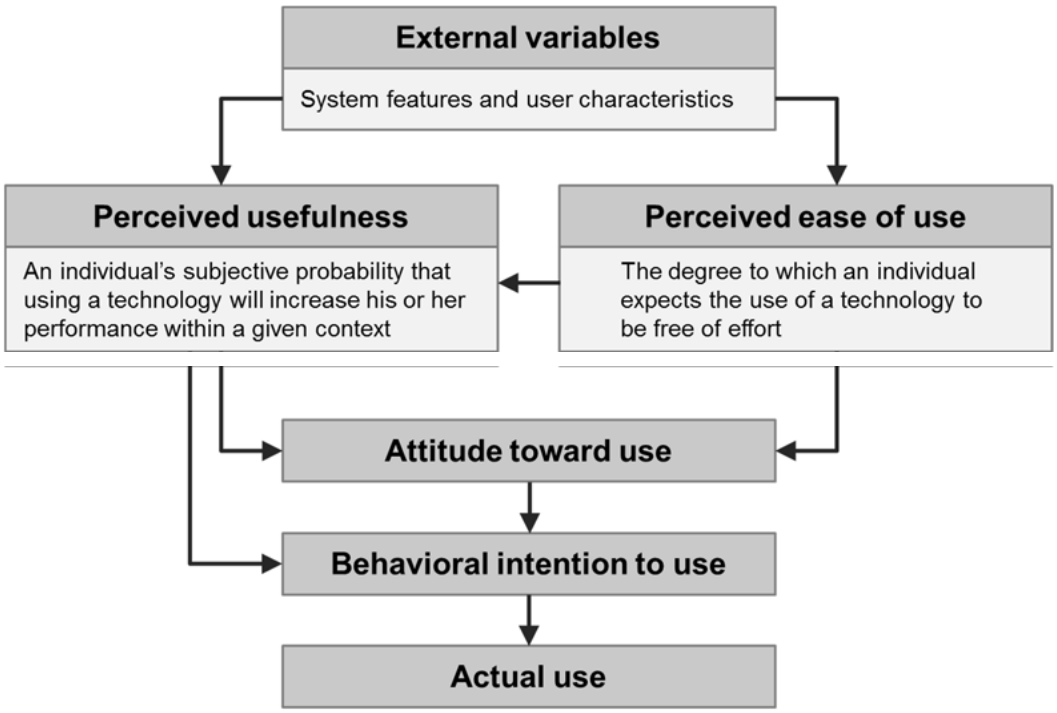

Figure 1. Technology Acceptance Model (TAM)
Source: Figure from Lee (2014), adapted from Davis (1989)

The constructs of usefulness and ease of use have remained central to understanding users' willingness to adopt a technology. Across different domains, a direct influence of *perceived usefulness* on acceptance of a technology has been consistently observed (Davis et al., 1989; Lee et al., 2015a; Lee et al., 2017; Venkatesh et al., 2003; Zhou et al., 2010). Several studies have also found direct correlations between *perceived ease of use* and behavioral intentions to use (Brown & Venkatesh, 2005; Chung et al., 2010; Lee et al., 2015a; Pan & Jordan-Marsh, 2010), while others have observed an indirect effect of ease of use on intention to adopt via perceptions of usefulness. In other words, the perception of easiness to use may be folded into an overall perception of a technology's usefulness in determining a person's willingness to adopt. For example, Porter and Donthu (2006) found statistical evidence that individuals who perceive the internet as easy to use also perceive it as more useful, compared to those who perceive the internet as more difficult to use.

Perceived usefulness and perceived ease of use of a technology are naturally related to the *objective characteristics* of that technology – what TAM refers to as the "system features" that the user observes. These characteristics can include the performance (or lack of performance) of the device (Phillips & Zhao, 1993), design compatibility (Mallat et al., 2008), and the design of the user interface (Sarker & Wells, 2003).

Individual perceptions of a technology also are informed by what TAM refers to as *user characteristics,* including age, education, income, cultural background, technology self-efficacy, and life stage. Self-efficacy may determine a user's perceptions of the ease of use of a device (Venkatesh & Davis, 1993), and self-efficacy may further be related to demographic characteristics like age and gender. In a study showing the effect of age, education, income, and race on technological attitudes, Porter and Donthu (2006) found that people who are younger, more highly educated, wealthier, and white have more positive attitudes toward using the internet.

Unified Theory of Acceptance and Use of Technology (UTUAT)

While TAM refers to individuals' backgrounds as an external variable in determining their attitudes and intentions toward technologies, it does not separate out demographic differences such as age and gender as specific variables. It also does not account for the effect of perceived *social influences and norms* on individuals' attitudes and intentions toward a technology. Social factors, such as subjectively perceived norms and peer support, and individual characteristics, including age, gender, and self-efficacy, are often related. These relationships may be significant for understanding, for example, differences in technology adoption behaviors between older people and younger people. In a study on software use, Morris and Venkatesh (2006) found that older people were more strongly influenced by subjective norms in developing attitudes toward new software compared to younger people.

Showcasing the development and expansion of theories on technology adoption since TAM in 1989, a larger integrated framework by Venkatesh et al. (2003), called the Unified Theory of Acceptance and Use of Technology (UTAUT) model, incorporates demographic factors and social influences. As with TAM, perceived ease of use and perceived usefulness are accounted for in the model by the synonymous (if not equivalent) concepts of "effort expectancy" and "performance expectancy," respectively. UTAUT was later extended and renamed as UTUAT2 (Venkatesh, Thong, & Xu, 2012); the extended model is shown in Figure 2.

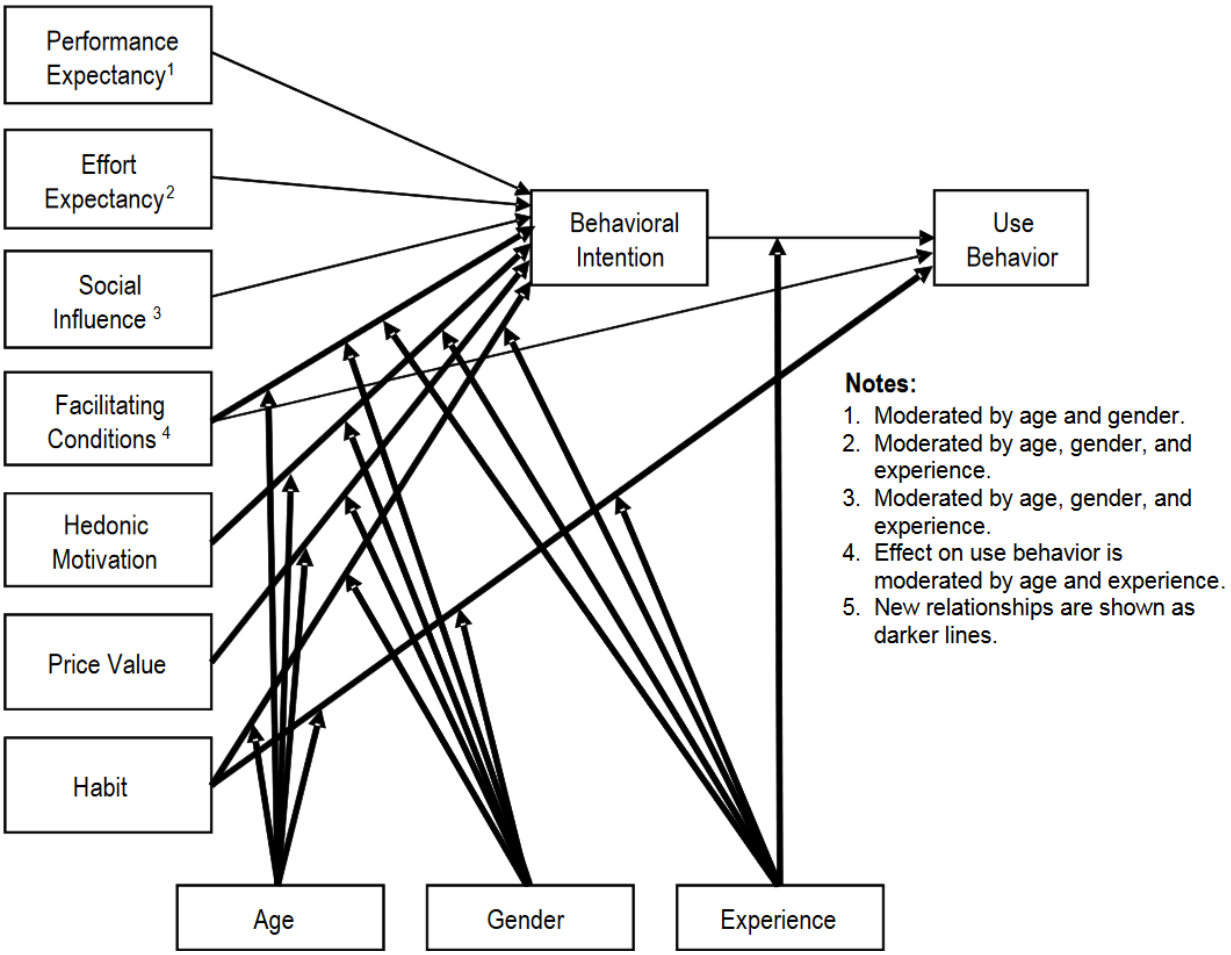

Figure 2. Extended Unified Theory of Acceptance and Use of Technology (UTUAT2)
Source: Venkatesh, Thong, & Xu (2012)

Compared to TAM, the UTAUT2 model greatly expands the number of variables considered to influence technology adoption behavior. Past *experience* with using technologies affects one's effort expectancy of adopting a new technology. The variables of "price value" (that is, the perceived cost of the technology), "habit," and "hedonic motivation," or how enjoyable the technology is to use, are also included. The model also accounts for moderating effects between these variables.

The number of variables and interrelationships in this model demonstrate the complexity of technological adoption as a phenomenon, and the wide range of potential factors that can be considered as influences on adoption attitudes and behaviors. However, critics of UTUAT2 have also claimed that the model is complex to the point of being chaotic (Bagozzi, 2007).

Technology Adoption Factors among Older Adults

The complexity of UTUAT2 as a model may make it difficult for designers and other practitioners to utilize. One possible way to narrow the examination of technology adoption as a phenomenon is to center on a particular social group. For example, researchers at the MIT AgeLab constructed a technology adoption framework that is applicable to the general population but is primarily focused on older adults (Lee, 2014; Lee & Coughlin, 2015). The authors conducted a systematic review of prior literature discussing older adults, technology adoption, and technology acceptance. From the review they uncovered twelve primary factors influencing older adults' adoption behavior. Additionally, interviews were conducted with older adults around their technology experiences and related decisions to uncover and describe factors that were not captured in past studies.

As with TAM, ease of use (here referred to as *usability*) and usefulness (referred to as *value*) are important factors, as well as a third construct called *reliability*, which refers to expectations about how the technology will work, and whether it will work as expected, over time. Older adults are more likely to adopt a technology when they perceive its usefulness and potential benefit, rather than for mere novelty or the "hedonic benefit" of the technology. Adoption is also more likely to be achieved if a technology demonstrates a clear purpose and benefits to the older user (Eisma et al., 2004; Kang et al., 2010; Lam & Lee, 2006). In addition to the factors of usability and value that appear in general models of technology adoption, the framework suggests other variables that may be significant in determining older adults' acceptance of new technologies. For example, considerations of familiarity, confidence, conceptual compatibility, and technical support are likely to be more important for older adults. Also, social dimensions need to be considered to ensure that the design and operation of a technology do not stigmatize its users and that the use of a technology can be supported by peers and family. All factors are described in Table 1 below.

Implications

Since 1989, the empirical research, literature, and conceptual complexity related to technology adoption have grown significantly. TAM, the first model discussed in this overview, observes four key variables – user characteristics, device features, perceived usefulness, and perceived ease of use – all of which have been consistently validated as key determinants of technology adoption. However, later research and frameworks attend to a larger array of factors, especially the social context under which an individual encounters a new technology. Subjective norms, the presence of social and technical support, and peer behavior may all contribute significantly to technology adoption behavior. Attention to the specific effects of demographic factors such as age, education, and gender is also important for developing a more complete understanding of technology adoption.

Table 1. Descriptions of relevant technology adoption factors for older adults.

Factor		Description
Usability		Perception of user friendliness and ease of learning. Also called perceived ease of use.
Value		Perception of practical usefulness and potential benefit. Also called perceived usefulness.
Affordability		Perception of potential cost savings versus initial investment. High cost drives older adults away from using technology. While it is important for a technology to be practical and easy to use, being affordable is also essential.
Accessibility		Knowledge of the technology's existence and its availability in the market. Older adults are generally less aware of new technologies that could be helpful to them (Heinz et al., 2013).
Technical Support		Availability and quality of professional assistance throughout use. Partly due to the unavailability of technology education and experience in the earlier stages of their lives, technical support and proper coaching are essential for older adults' adoption (Demiris et al., 2004; Moore, 1999; Poynton, 2005; Wang et al., 2010).
Social Support		Support from family, peers, and community. People within older adults' social groups, such as family, friends, and community members, play an important role in the adoption process, acting as "technology champions" (Wang et al., 2010).
Emotion		Perception of emotional and psychological benefits. While the possibility of positive emotional and social impacts can drive adoption, the potential threat of decreased social connectivity and emotional contact can hinder technology adoption.
Independence		Perception of social visibility or how a technology makes the user look to others. A design that can potentially make older adults appear dependent, frail, or in need of special care can discourage adoption and use, while a universally appealing design may be more acceptable.
Experience		Relevance of the technology's function with the user's prior experiences and interactions. When introduced to a new technology, people reference other familiar systems to understand its purpose and determine their perception and intention to use (Brown & Venkatesh, 2005).
Confidence		Level of belief or anxiety over whether the user will be able to utilize the technology effectively, given their abilities. While many older adults are in fact interested in using new technologies, their level of confidence in interacting with high-tech devices is generally lower than that of younger people.
Reliability	**System reliability**	Perception that the technology will work as expected over time.
	Service trust	Perceived dependability of a company or organization that produces and provides the technology.
Compatibility	**Interoperability**	Perception that the technology will work within an existing framework of devices and services.
	Lifestyle fit	Perception that the new technology will seamlessly be integrated into a user's existing life patterns.
	Conceptual fit	The degree to which how the technology works matches a user's existing mental models. The perceived match between how the system operates, including its language and symbols, and how a user understands and explains events, changes and relationships based on their prior knowledge.

Source: Adapted from Lee (2014) and Lee & Coughlin (2015).

On the other hand, presenting a comprehensive general framework of technology adoption that includes all the factors listed above, and more, as with UTUAT2, may create a model that becomes difficult to instrumentalize due to its complexity. One possible way to respect the complexity of technology adoption as a phenomenon while constraining a descriptive model from reaching unreasonable proportions may be to focus only on a particular social or user group, such as older adults, and uncovering those factors that are especially pertinent to that particular group.

However, researchers and developers should not allow a special understanding of a particular group's behavior to lead to inflexible thinking or stereotyping. It is fair to expect that characteristics of a technology such as hedonic motivation or novelty (see Carstensen, 1992) will tend to be more attractive to younger people than to older adults, and that these factors may not act as a "tipping point" for adoption among older users, as they might among younger users. On the other hand, as described in Lee (2014), the MIT AgeLab's model of older adults' technology adoption presents emotional benefits as a possible driver to acceptance and use, suggesting that hedonic motivation may be a significant factor, and that the potential for fun and enjoyment should be also be considered along with functional and practical factors in the design of technologies intended to be adopted by older adults.

Similar to older adults, we might expect that *caregivers* also demonstrate special characteristics in their technology adoption behavior. A technology adoption framework that focuses specifically on caregivers as a group may uncover, emphasize, or submerge factors in ways that contrast with the models that have been described above. For example, perceived ease of use may have a greater impact on caregivers' adoption behaviors as they consider the need for both they and their care recipient to be able to use the technology. And other factors highlighted in the models, such as independence, may not be as significant. While a general model of adoption such as TAM may represent a starting point for understanding technology adoption among a subgroup such as caregivers, further research should be conducted to identify the factors that primarily determine caregivers' adoption behavior specifically.

References

Bagozzi, R. (2007). The legacy of the Technology Acceptance Model and a proposal for a paradigm shift. *Journal of the Association for Information Systems*, *8*(4), 244–254. https://doi.org/10.17705/1jais.00122

Brown, S., & Venkatesh, V. (2005). Model of adoption of technology in households: A baseline model test and extension incorporating household life cycle. *MIS Quarterly*, *29*(3), 399. https://doi.org/10.2307/25148690

Carstensen, L. L. (1992). Social and emotional patterns in adulthood: Support for socioemotional selectivity theory. *Psychology and Aging*, *7*(3), 331–338. https://doi.org/10.1037/0882-7974.7.3.331

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319. https://doi.org/10.2307/249008

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, *35*(8), 982–1003. https://doi.org/10.1287/mnsc.35.8.982

Demiris, G., M. J. Rants, M. A. Aud, K. D. Marek, H.W. Tyrer, M. Skubic, and A. A. Hussam (2004). Older adults' attitudes towards and perceptions of "smart home" technologies: A pilot study. *Medical Informatics and the Internet in Medicine* 29 (2): 87–94.

Eisma, R., Dickinson, A., Goodman, J., Syme, A., Tiwari, L., & Newell, A. F. (2004). Early user involvement in the development of information technology-related products for older people. *Universal Access in the Information Society*, *3*(2), 131–140. https://doi.org/10.1007/s10209-004-0092-z

Heinz, M., P. Martin, J. A. Margrett, M. Yearns, W. Franke, H. Yang, J. Wong, and C. K. Chang (2013). Perceptions of technology among older adults. *Journal of Gerontological Nursing* 39 (1): 42–51.

Kang, H. G., Mahoney, D. F., Hoenig, H., Hirth, V. A., Bonato, P., Hajjar, I., Lipsitz, L. A., & for the Center for Integration of Medicine and Innovative Technology Working Group on Advanced Approaches to Physiologic Monitoring for the Aged. (2010). In situ monitoring of health in older adults: Technologies and issues. *Journal of the American Geriatrics Society*, *58*(8), 1579–1586. https://doi.org/10.1111/j.1532-5415.2010.02959.x

Lam, J. C. Y., & Lee, M. K. O. (2006). Digital inclusiveness—longitudinal study of internet adoption by older adults. *Journal of Management Information Systems*, *22*(4), 177–206. https://doi.org/10.2753/MIS0742-1222220407

Lee, C. (2014). User-centered system design in an aging society: An integrated study on technology adoption. Doctoral dissertation, Massachusetts Institute of Technology.

Lee, C., & Coughlin, J. F. (2015). Older adults' adoption of technology: An integrated approach to identifying determinants and barriers. *Journal of Product Innovation Management*, *32*(5), 747–759. https://doi.org/10.1111/jpim.12176

Lee, C., Mehler, B., Reimer, B., & Coughlin, J. F. (2015a). User perceptions toward in-vehicle technologies: Relationships to age, health, preconceptions, and hands-on experience. *International Journal of Human-Computer Interaction*, *31*(10), 667–681. https://doi.org/10.1080/10447318.2015.1070545

Lee, C., Raue, M., D'Ambrosio, L., & Coughlin, J.F. (2018). Technology adoption and digital self-service interactions: A literature overview. Report to the Hartford Center for Mature Market Excellence.

Lee, C., Ward, C., Raue, M., D'Ambrosio, L., & Coughlin, J. F. (2017). Age differences in acceptance of self-driving cars: A survey of perceptions and attitudes. In J. Zhou & G. Salvendy (Eds.), *Human Aspects of IT for the Aged Population. Aging, Design and User Experience* (Vol. 10297, pp. 3–13). Springer International Publishing. https://doi.org/10.1007/978-3-319-58530-7_1

Mallat, N., Rossi, M., Tuunainen, V. K., & Öörni, A. (2008). An empirical investigation of mobile ticketing service adoption in public transportation. *Personal and Ubiquitous Computing*, *12*(1), 57–65. https://doi.org/10.1007/s00779-006-0126-z

Moore, R. (1999). The technology adoption process: The adoption of business solutions. Available at: http://www.information-management.com/issues/19990301/127-1.html.

Morris, M. G., & Venkatesh, V. (2000). Age differences in technology adoption decisions: Implications for a changing work force. *Personnel Psychology*, *53*(2), 375–403. https://doi.org/10.1111/j.1744-6570.2000.tb00206.x

Pan, S., & Jordan-Marsh, M. (2010). Internet use intention and adoption among Chinese older adults: From the expanded technology acceptance model perspective. *Computers in Human Behavior*, *26*(5), 1111–1119. https://doi.org/10.1016/j.chb.2010.03.015

Phillips, B., & Zhao, H. (1993). Predictors of assistive technology abandonment. *Assistive Technology*, *5*(1), 36–45. https://doi.org/10.1080/10400435.1993.10132205

Porter, C. E., & Donthu, N. (2006). Using the technology acceptance model to explain how attitudes determine Internet usage: The role of perceived access barriers and demographics. *Journal of Business Research*, *59*(9), 999–1007. https://doi.org/10.1016/j.jbusres.2006.06.003

Poynton, T. A. (2005). Computer literacy across the lifespan: A review with implications for educators. *Computers in Human Behavior* 21 (6): 861–72.

Sarker, S., & Wells, J. D. (2003). Understanding mobile handheld device use and adoption. *Communications of the ACM*, *46*(12), 35–40. https://doi.org/10.1145/953460.953484

Venkatesh, V., Morris, M., Davis, G., & Davis., F.D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, *27*(3), 425. https://doi.org/10.2307/30036540

Venkatesh, Thong, & Xu. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. *MIS Quarterly*, *36*(1), 157. https://doi.org/10.2307/41410412

Venkatesh, V., & Davis, F. D. (1996). A model of the antecedents of perceived ease of use: Development and test. *Decision Sciences*, *27*(3), 451–481. https://doi.org/10.1111/j.1540-5915.1996.tb01822.x

Wang, A., L. Redington, V. Steinmetz, and D. Lindeman (2010). The ADOPT model: Accelerating diffusion of proven technologies for older adults. *Ageing International* 36 (1), 29–45.

Zhou, T., Lu, Y., & Wang, B. (2010). Integrating TTF and UTAUT to explain mobile banking user adoption. *Computers in Human Behavior*, *26*(4), 760–767. https://doi.org/10.1016/j.chb.2010.01.013