The Digital Divide and Older Adult Population Adoption, Use and Diffusion of Mobile Phones: A Quantitative Study

Abstract.

Due to the changing demographics of societies around the world, ageing has become a major concern for governments and policy makers alike. What has also become clear is that the older adult consumer group and the factors affecting this age group have been studied relatively less in the literature. In this paper, we aim to investigate the adoption, usage, and diffusion of smartphones within the UK older adults so as to identify the factors encouraging or inhibiting smartphone usage and service provision within this age group. To this end, we propose a conceptual framework (Model of Smartphone Acceptance) based on a set of well-known theories of adoption and diffusion. We collected data from 984 participants living in north London and applied the Partial Least Square Structural Equation Modelling (PLS-SEM) technique to analyse the data. Our research can contribute towards reducing some of the existing digital divide within UK older adults. Moreover, businesses can benefit from our research by understanding the significant factors affecting the adoption of smartphones among the UK older population and to adapt their policies accordingly.

Keywords: Smartphones, Adoption, Older adults, Quantitative, United Kingdom, North London.

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1. Introduction

In the last decade, the capabilities and functions of Information and Communication Technologies (ICTs) have significantly advanced, particularly in terms of mobility and availability (24 hours, 7 days a week). These advances in ICT devices, such as, laptops, tablet devices and mobile phones like smartphones, have led to their gaining an important role in the business, education and personal lives of individuals. Their roles include providing information that is expedited, easily accessible and managed (Line et al. 2011; Condie and Munro, 2007; Galloway et al., 2004; Selwyn et al., 2003).

This paper is focused on smartphones, which is generally defined as an advanced form of mobile phones that offer much flexibility in the form of 24 hours, 7 days a week access and faster communication between individuals, whether in their personal or work lives (Yueh et al., 2016). When considering an appropriate definition for research purposes, difficulties persist as each definition varies according to the research focus. For our study, a smartphone is defined as a combination of the following explanations: A smartphone is a small-scale information system that technically has the following assets: It is a mobile phone with advanced capabilities, which executes an identifiable operating system allowing users to extend its functionality with third party applications that are available from an application repository. According to this definition, smartphones must include sophisticated hardware with: a) advanced processing capabilities (e.g. modern sensors), b) multiple and fast connectivity capabilities (e.g. Wi-Fi), and (optionally) c) adequately limited screen sizes. Furthermore, their Operating Systems (OS) must be clearly identifiable; e.g. Android, Blackberry, Windows Phone, Apple's i-phone Operating Systems (iOS). Finally, the OS must allow third party application installation from application repositories ('app markets'), e.g. Android Market, BlackBerry App World, App Hub, App Store (Theoharidou et al, 2012).

An important function that mobile phones have recently been viewed pertinent for is functions allowing a reduction in social exclusion due to the advanced features; eg. voice over internet protocol applications (eg. Skype, Viber) that allow free calls and the viewing of photographs and real time communication as this affects wellbeing and happiness (Dennis et al., 2016). As ageing occurs, mobility is affected, which can lead to isolation for individuals and a solution for such problems is viewed to be the smart, or mobile phones (Dennis et al., 2016). Specifically, the smart phone is viewed to be a solution for isolation as its functions allow entertainment and social interaction due to applications such as, Youtube, Facebook, the internet and communication. Research has found that higher levels of support are provided by ICTs such as, smart phones, which ensure a reduction, even if it is a small amount, of social isolation (Heo et al, 2015).

From 1996 the smartphones consumer market grew to become one of the fastest developing novel technologies in the mobile phone market. The most famous brand of mobile phones is the Apple iPhone that was introduced to the market in 2007, and subsequently has become ubiquitous all over the world. It is estimated that about half the adult population in the world owns a smartphone that will rise to 80% by 2020 (Economist, 2016). Benefits of smartphones include the provision of information and knowledge on entertainment, travel, finance, healthcare, lifestyle, photography and social networks in an expedited and easily accessible manner (Xu et al., 2011). In the workplace, smartphones have led to a blurring of the boundaries between the home and workplace (Fujimoto et al., 2016). Since their

introduction, there have been an estimated 1 billion smartphones in the consumer market, with mobile subscriptions growing at approximately 4 percent year-on-year, reaching 7.6 billion in Q1 (Ericsson Mobility Report, 2017; Rushton, 2012).). Statistics show that the number of smartphone owners in the UK have increased continuously from 21.6 in 2011 to 36.4 in 2014 and expected to increase to 46.4 until 2018 (Ofcom, 2015). The numbers also illustrate that there are usage gaps between the older adults and adults in general. In 2014, 17% of the 65 years old and above population compared to 49% of the 55-64 years and 84% of 35-44 age groups were smartphone users (Ofcom, 2015).

One of the major achievements of the 20th century is the considerable increase in life expectancy, which is termed as the ageing population. Due to medical advances and better quality of life, individuals are living longer (United Nations, 2010). From a national survey in the UK conducted in 2012, 16.4% of the UK population were older than 65 years old, with around 40% of them being older than 45 years old (Office of National Statistics 2010). When considering older adults, there are categories that have been formed to differentiate between older adult individuals. More specifically, there are three categories when explaining older adults: Pre-seniors (aged 50-64); young-old (aged 65-74); and older-old (aged 75+) (Lee et al, 2011).

To provide a more in-depth picture of the UK and its ageing population, individuals aged 65 or over increased by 3.8 percentage points between 1974 and 2014; ie.from 13.8% of the UK population to 17.7%. This proportion is projected to increase by a further 6.6 percentage points of the UK population by 2039 (Office for National Statistics, 2016). Ageing can bring about numerous challenges to any government such as, increased government spending on healthcare, shortage of workers, and negative effects on productivity and economy growth. This brings about challenges to policy makers as predictions show that by 2040, one in seven people is projected to be aged over 75 (www.gov.uk) and two-fifths of the National Health Service (NHS) budget will be spent on people over 65 (theguardian.com).

For the older adult population, ICTs, including online social networks, such as Facebook and smartphones are viewed advantageous since they can aid health care (Joe and Demirtas 2013), or a reduction in loneliness by connecting older adults with their friends and family (Dennis et al., 2016; Choudrie and Vyas, 2014). Socio-demographic analysis of users revealed that younger adults (50 years and below) are in the majority, with older adults being fewer in number; however, still growing in numbers. The vast majority (90%) of 16-24 year olds own smartphones; but 55-64 year olds are also joining the smartphone revolution, with ownership in this age group more than doubling since 2012; ie.from 19% to 50% (Ofcom, 2015). Older adults are also important for economies as they are wealth creators and holders, but yet they are ignored, or not recognised as the following statements show: “The 50-plus generation is at best ignored and at worst patronised, which, given that by the year 2020 half of the UK population will be 50-plus, is both bizarre and unacceptable” (Marketing Week, 2014). “Many older adults report frustrations that companies selling products to them don’t treat them like the intelligent and discerning consumers they are” (Nesta, 2016). For a better understanding of the research in social networks and older adults, one can refer to Coelho and Duarte (2016). In a relevant study to ours, Yusif et al. (2016) reviewed the main barriers in the adoption of assistive technologies for older adults and found that privacy is the most significant concern in this age group.

The differences existing in the ways that individuals use and accept innovative technologies including ICTs are associated with characterizations that are widely referred to as 'the digital divide' (Tsatsou, 2011). Large numbers of studies have been undertaken of older and younger adults where emphasis has been drawn upon the social capital divide that exists between the older and younger population's

internet and computer use and electronic commerce (Wagner et al., 2010; Passyn et al., 2011). As an example, comparing different age and gender groups (Lian and Yen, 2014) found that different age groups (under 35 vs. 35-50 vs. over 50) have diverse perceptions towards online shopping (Dennis et al., 2016). Understanding the older adult population is also pertinent for businesses as they can then cater to the needs and requirements of this demographic group, an issue highly emphasised in the United States of America (USA); particularly given that governments and organizations, including marketing businesses are gaining immensely due to the internet based strategies (Porter and Donthu, 2006).

As explained earlier, smartphones can provide convenience and benefits to various users; including the older adult population (Kim and Hwang, 2012). As Kim and Hwang (2012) found diverse users have different uses that content and mobile device providers need to concentrate upon. Additionally, although there are increases within the older adult population adopters, there are still many older adults who have not adopted the devices. For businesses developing and implementing internet based strategies the older consumer not adopting smartphones implies a future opportunity for potential sales and profits. Acknowledging that smartphones and older adults are both important changes for society and organizations alike and that smartphone potentials cannot be reaped without their wider proliferation, this study addresses these gaps by identifying the adoption, usage, and diffusion of smartphones in the older adult population of the UK. The academic contribution of this research is the identification of factors encouraging or inhibiting the acceptance of smartphones within the older adult population in North London. Although this is focused on North London, synergies can also be drawn with other older adults across the country, or the globe. The remainder of this paper is organised as follows: A literature review of the relevant research to our study is provided in section (2). The research methodology of the study is then presented in section (3) and main findings are provided in section (4). Discussions on the research findings are given in section (5) and conclusions are provided in section (6).

2. Literature Review

2.1. The Digital Divide, Older Adults, the Challenges of Ageing, and smartphones

The existing differences in the ways that individuals use and accept their ICTs and innovative technologies are associated with characterizations termed as 'the digital divide' (Tsatsou 2011). Differences between users can be associated with the digital divide that has been conceptualized as operating in three levels, namely: (1) The global divide refers to the divergence of internet access between industrialized and developing countries; (2) The social divide concerns the gap between information rich and information poor in each nation; and (3) The democratic divide signifies the difference between those who do, and those who do not, use the panoply of digital resources to engage, mobilise, and participate in public life (Norris 2001). A basic strategy for overcoming the digital divide is to provide physical access to computers; but, as Warschauer (2004) clarifies there are three further resources aspects to be considered, which are: digital resources (material made available online); human resources (in particular literacy and education) and social resources (the community, institutional and societal structures that support access to IT).

The digital divide is essential for social inclusion as the internet is useful for making large decisions (Horrigan & Rainie, 2006). When considering social inclusion, the concept of social exclusion also arises. Social exclusion is a policy concept term that emerged in France in the 1970s and defined as: “social categories of people who were unprotected under the government’s social insurance system (de

Haan, 2001; de Haan, 1999; Silver, 1994). From the time it was introduced, the term has undergone changes in understanding and interpretation. In the 1980s Mitterrand's socialist government in France transformed into a new model of anti-exclusion social policies and ever since then, the term has been used in diverse contents in the UK and EU (Notley and Foth, 2008).

When considering the policy facets of social exclusion/inclusion, reference is made to the debate about what it means to be excluded from society and how different political and social structures should address this in a consistent way. This is then associated with Sen's (2000) development concepts where the context-specific analysis is used to understand the 'root causes of deprivation'. Research has suggested that if the digital inclusion aspect is considered, then the digital divide moves from a singular focus on technology access and towards a focus on the way technology access and use can impact different forms of deprivation and disadvantage (Warschauer, 2003).

In business and consumer research, social exclusion has been explained in several ways (Atkinson, 1998): (1) multiple deprivation, which is more than being financially poor or unemployed and includes not having a community or the ability to interact socially; (2) relativity which is people excluded from society at a specific place and time; (3) agency: where people or agents experience either voluntary or involuntary exclusion; and (4) dynamics: where people could become unemployed, experience financial pressure, or have fewer opportunities to prosper in the future. Burchardt, et al. (1999) extended this explanation to define social exclusion as: "an individual is socially-excluded if (a) he or she is geographically resident in a society, (b) he or she cannot participate in the normal activities of citizens in that society, and (c) he or she would like to participate but is prevented from doing so by factors beyond his or her control.

For businesses digital divideis important as countries that have reduced their citizens and consumers digital divides with the provisions of ICTs skills and knowledge are faring better than those that are not (Antonelli, 2003). As suggested by Freeman and Louca (2001): "ICTs is the result of a bundle of both product and process innovations which apply to a wide variety of activities and reflect the characteristics of the innovating countries and emphasize their structural characteristics. Their international diffusion is pushed worldwide by their strong effects in terms of profitability of adoption and rates of increase of total factor productivity."

For our research, the digital divide is defined as the division between those who have access to a technology and those who do not (Curwen and Whalley 2012). This definition was selected because within the older adults' demographic group, there are some individuals who do not have access to smartphones due to the issue of cost. There is no access also due to personal preferences, or due to their personal network containing individuals who have no interest, knowledge, or information on the benefits of smartphones, which leads to no access. Further, this was the most recent definition applicable to current situations. It is also posited that the digital divide (or the global digital divide) is generally referred to as the uneven diffusion, gap or disparities between different socio-economic levels across countries or between developed and developing nations in terms of access and use (usage) of ICT (Hwang, 2006). Typically, the digital divide refers to internet access, but the term has been broadened to include other ICTs (Anheire and Toepler, 2009; Chang et al, 2012) as well.

Generally, it is known that there is a divide in the way different groups of society use their mobile devices, but literature has also found that one significant component of the digital divide is age (Selwyn et al., 2004). Having lived many years in the world without the internet, older adults tend to perceive the internet as a "non-essential" part of their lives and do not want to use the newer internet enabled devices and services. Additionally, age-related problems such as, declining eyesight and arthritis are

major challenges to overcome when viewing computer screens and using related hardware such as keyboards. This has brought about a significant age-based divide between the young and old with internet use declining in every advancing age group (Greengard, 2009). There are various definitions of older adults in the literature. For this study, the older adult population is defined as the people above 50 years old and above (Netlingo, 2010). Smartphones are viewed as important for older adults as they may provide health care benefits (Joe & Demiris, 2013), and a reduction in loneliness by connecting older adults with their friends and family (Blažun et al, 2012).

Several research studies have attempted to study the digital divide in order to identify the factors leading to the age-related digital divide such as, lack of perceived need (Mann et al., 2005; Melenhorst et al. 2006; Chang et al, 2012), lack of interest or motivation (Carpenter et al., 2007; Selwyn et al., 2003), lack of knowledge (Peacock and Kunemund, 2007), lack of access (Peacock and Kunemund, 2007), cost (Mann et al. 2005; Carpenter et al., 2007), and physical limitation (Saunders, 2004; Carpenter et al., 2007).

Vuori and Holmlund-Rytkonen (2005) found that an estimated one-third of the Finnish population do not use the Internet. In Australia's older adults population it was found that the internet is used five times less than the under 30s age group (Willis, 2006). In the Netherlands, socio-demographic variables were studied to find the relationship of internet use and the type of Internet usage, which led to the conclusion that age is a significant factor in internet usage as the younger generation uses the internet as communication and entertainment tools while older adults use the internet for buying products online, sending emails, and searching for health-related issues (Van Deursen and Van Dijk, 2013). This finding can be seen in other populations as well when considering the concerns of elderly people with regards to their health-related problems such as, diabetes, hearing impairments, poor vision, and strokes (Sun and Qu, 2015). In Thailand, smartphones were a panacea to older adults' health problems as they could be employed for e-health services adoption (Boontarig, 2012; Sun and Qu, 2015). Besides physical health problems, some older adults could face mental issues such as, depression, social isolation, decreased social contact or lack of emotional support. Cotten et al. (2012) examined the link between depression and internet use within the American older adults. The results indicated a positive correlation between internet use and mental well-being of retired older adults. Internet use was found to reduce the probability of a depression categorisation for older participants by about 20-28% (Cotten et al., 2012). The products offered by smartphones, application platforms are also seen as solutions to assessment of mental related diseases within older adults in the UK (Sangha et al, 2015).

However, excessive use of mobile phones can lead to problems for the younger generation, and also for the older adults. In South Korea, German researchers found that excessive use of mobile devices could lead to a "digital Dementia", a term that describes the overuse of digital technology resulting in the breakdown of cognitive abilities in a way that is more commonly seen in people who have suffered a head injury or psychiatric illness (Spitzer, 2012). Within the younger generation, aged mainly between 25 and 45, it has been found that treatment traditionally offered to older generations for conditions such as, varicose veins, haemorrhoids, back pain and knee joint problems, was increasingly being sought by younger adults, a shift attributed to time spent sitting at desks, watching box sets and using smartphones and tablets (Forster, 2016).

Bearing the benefits and drawbacks of smartphones in mind, it has been learnt that several research studies have attempted to study older adults and their adoption, use and diffusion of smartphones and to identify the factors leading to the age related digital divide. These factors are viewed to be in theoretical terms the factors of perceived lack of benefits (Mann et al., 2005; Melenhorst et al., 2006),

lack of interest or motivation (Carpenter and Buday, 2007; Selwyn et al. 2003), lack of knowledge (Peacock and Kunemund, 2007), lack of access (Peacock and Kunemund, 2007), cost (Carpenter and Buday, 2007; Mann et al. 2005), and physical limitation (Carpenter and Buday, 2007; Saunders, 2004). Recently, Macedo (2017) evaluated the predictive relevance of UTAUT2 to explain the behaviour and intention of older adults to use ICTs technologies in general and reported that a variety of its predictors contribute to the intention of older adults to use these technologies. These studies showed that previous older adults and smartphone research studies have identified factors leading to the adoption, use and diffusion of smartphones. However, there are other factors such as, observability, compatibility and other factors that have not been researched in these studies; thus, building a further motivation to this team to undertake a research study of older adults and smartphone adoption, use and diffusion. The next section identifies the detailed factors of research interest to this study, the theory used for building the conceptual framework and the hypothesis leading this study.

2.2. Theory Building and Hypothesis Development

Despite the large numbers of studies in the information systems, and business subject areas, research associated with adoption and novel internet-related products and services is still developing. The main theories applied in adoption studies are the Diffusion of Innovation (DoI) theory (Rogers, 1998); Unified Theory for the Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003; Venkatesh et al., 2012); Technology Acceptance Model (TAM) (Davis, 1989), and Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980). A comprehensive study of the literature shows that TAM is the most popular classic adoption theory applied to IS and adoption research, followed by UTAUT and TRA (Aldhaban, 2012). However, there was also a preference towards combining two or more classic IS adoption and use theories for research. For instance, DoI and TAM were combined to explain the adoption of smartphones in a logistic industry (Chen et al., 2009). This combination was also applied to research the adoption of smartphones within medical practitioners, doctors and nurses (Park and Chen, 2007II). UTAUT and enjoyment were combined to examine the importance of enjoyment in mobile services (Song and Han, 2009).

The proposed conceptual framework for this research has assumed that the dependent variable of this research, the behavioural intention to use and adopt smartphones of older adults is influenced initially by observability and compatibility that have been drawn from DoI (Rogers, 1998). The second group of constructs include social influence, facilitating conditions, performance expectancy and effort expectancy that are drawn from UTAUT (Venkatesh et al., 2003; Venkatesh et al. 2012) Thirdly, perceived enjoyment (Chtourou and Souiden, 2010; Song and Han, 2009) has been also integrated in the model.

Finally, the dependent variable, actual use is influenced by the intention to use smartphones. Usage was measured by the features of a smartphone, such as sending e-mails, browsing, using social media, taking a photo, and playing games. The following sub-section presents the hypothesis applied to this research and its supporting literature.

2.2.1. DoI: Observability

An innovative product is defined as a new product where the features are novel or improved significantly from the predecessors (Rogers, 2003). The contemporary features may be developed using innovative technologies and knowledge or materials currently available (Rogers, 2003). Therefore, smartphones can be innovative products because firstly, they were introduced in 2007 with advanced designs and sophisticated technologies such as an iPhone (Honan, 2007). Secondly, they had

applications and immense advanced features compared to a feature phone. Hence, Rogers's DoI is a valid tool to be used in our research.

Observability is defined as the degree that smartphones are visible to older adults (Rogers, 2003). Previous research studies pertaining to smartphones also identified that observability is important for technology adoption. Observability was applied and confirmed in the study of smartphone adoption among doctors and nurses (Park and Chen, 2007II) in mid-west, USA. It was also applied to study smartphone adoption among nurses in community hospitals in south eastern USA (Putzer and Park 2010) and influenced the mobile commerce adoption within graduate degree students (Khalifa and Cheng, 2002), mobile banking (Al-Jabri and Sohail, 2012), also in the mobile internet context in China (Liu and Li, 2010).

In real life situations, Observability can emerge in instances where older adults who are in employment, are likely to observe smartphones being used by their younger co-workers. Older adults may also observe, or see smartphones being used by their children. Smartphone providers also widely advertise their products on several channels including traditional ones such as, television programmes, newspapers, and magazines. Contrastingly, when retired, the smartphone functions may be limited because the user will draw only from their experience and not what the smartphone advanced features can offer, which is more observable when interacting with many people in a work environment.

Therefore, from DoI, this research posits that there is more of a likelihood of older adults adopting smartphones when they see a smartphone being used. Thus the following hypothesis is proposed.

H1: Observability has a positive influence on the behavioural intention of smartphone adoption within older adults.

2.2.2. DoI: Compatibility

Compatibility is defined as: “the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters” (p. 15; Rogers, 2003). This variable has been studied in several past mobile and smartphone research studies. For example, Teo and Pok (2003) studied WAP-enabled mobile phones within internet users in Singapore and confirmed that compatibility can influence attitude and user behaviour. The effect of compatibility was also confirmed in mobile commerce adoption (Wu and Wang, 2005) and mobile banking (Lin, 2011) studies conducted in Taiwan. In the health care industry, compatibility was integrated and confirmed in healthcare systems using mobile devices (Wu et al., 2007). In a different study, Xu et al. (2012) applied compatibility to study accessing health informatics via smartphones and confirmed that compatibility influences intention to use among older women in Singapore.

In a more traditional perspective, smartphones or mobile phones are compatible with a business person's lifestyle. Smartphones can be used as communication tools to operate a business and to contact friends and family. As addressed earlier, smartphones can assist older adults in monitoring their health. There are myriad of applications for smartphones to help adults tackling memory loss problems, to track their activity levels, and keep in touch with their doctors. Therefore, it can be seen that smartphones can be compatible with an older adult's lifestyle leading to the proposal of the following hypothesis.

H2: Compatibility has a positive influence on the behavioural intention of smartphone adoption within older adults.

2.2.3. DoI: Social Influence

Social influence, one of the factors drawn from UTAUT, can be defined as the degree to which an individual perceives that important others such as, family members, or others believe he or she should use the new system (Venkatesh, 2012). It has been found that when older adults adopt new technologies, they are normally influenced by other individuals, particularly those who are close to them.

Previous research studies associated with smartphones emphasised the role of social influence on technology adoption, such as 3G adoption (Chong et al., 2012, Song and Han, 2009), mobile coupons (Chong et al., 2012), mobile phone adoption within older adults (Chong et al., 2012), online applications on smartphones (Shi 2009), smartphone application acceptance (Lee et al., 2011), analysis of users and non-users of smartphone applications (Verkasalo et al., 2010), the Thai older adults intention to use smartphone for e-Health services (Boontarig et al., 2012), and smartphone adoption in Bangkok (Pitchayadejanant et al., 2011). In our study, we propose the following hypothesis to be analysed.

H3: Social Influence has a positive influence on the behavioural intention of smartphone adoption within older adults.

2.2.4. UTAUT: Facilitating Conditions

Facilitating conditions drawn from UTAUT can be defined as the degree to which an individual believes that an organisational and technical infrastructure exists to support the use of a smartphone (Venkatesh, 2012). This factor can be explained by older adults having the necessary resources such as knowledge, time and money to adopt smartphones (Venkatesh et al., 2003; Zhou, 2008). However, as with any novel technology, users who want to adopt a smartphone will need to have some understanding of using the new device owing to the inherent differences of the new technologies to the old ones.

Additionally, the costs of using a smartphone such as its monthly fees are also included within the facilitating factor. Users tend to use a technology if its associated costs are affordable. From previous research studies on mobile acceptance, the construct facilitating conditions is viewed as to be a leading factor leading to acceptance/adoption of new technologies (Zhou et al., 2010; Zhou, 2008). The previous research studies integrate facilitating conditions such as acceptance of smartphone online application software in China (Shi 2009) and Singapore (Lee et al. 2011), intention to use smartphones in Thailand (Pitchayadejanant, 2011), Chinese mobile banking (Zhou et al., 2010), and mobile technology acceptance (Zhou et al., 2008).

In our study, the following hypothesis is proposed.

H4: Facilitating Condition has a positive influence on the behavioural intention of smartphone adoption within older adults.

2.2.5. UTAUT: Performance Expectancy

Performance Expectancy, which is also drawn from UTAUT, is defined as the degree to which an individual believes that using the system will help him or her to achieve completion of their jobs or tasks and is one of the factors that affects user behavioural intentions (Venkatesh, 2012). UTAUT identifies a user's perception of the smartphone benefits being mobility, internet connection and an application that can assist older adults in many ways as addressed in the reviewed literature. If older

users recognise the potential benefits that a smartphone can provide, they are likely to adopt and use a smartphone. The significance of performance expectancy has been studied in different studies all over the world such as, Yu (2012) and Chen (2011) in Taiwan, Park et al. (2007I) and He and Lu (2007) in China, Carlsson et al. (2006) in Finland, and Boontarig et al. (2012) in Thailand. In this study, the following hypothesis will be studied for the older adults living in north London.

H5: Performance expectancy has a positive influence on the behavioural intention of smartphone adoption within older adults.

2.2.6. UTAUT: Effort Expectancy

Effort expectancy is defined as the degree of ease associated with the use of a system (Venkatesh et al., 2012). It reflects the perceived effort construct when users adopt a new system, which in this case is a smartphone. Effort expectancy factor is compared to the perceived ease of use construct of TAM and the complexity construct from the DoI (Venkatesh et al., 2003). It explains a user's perception of the difficulty associated with using a smartphone. That is, whether using a smartphone is difficult or easy to master. Effort expectancy was integrated to study smartphone for health services adoption among the older adults of Thailand (Boontarig et al., 2012). Kijsanayotin et al. (2009) showed the significance of effort expectancy in a study of information system with health centres. In another study, Im et al. (2011) applied effort expectancy to study music players and mobile banking in Korea and USA. For mobile gaming, Chen (2011) applied the variable to study mobile gaming in China. Alkhunaizan et al., (2012) also applied effort expectancy to study mobile commerce in Saudi Arabia.

In this study, we propose the following hypothesis.

H6: Effort Expectancy has a positive influence on the behavioural intention of smartphone adoption within older adults.

2.2.7. TAM3: Perceived Enjoyment

Perceived enjoyment is defined as the extent to which the activity of using a specific system is perceived to be enjoyable in its own right, aside from any performance consequences resulting from the system use (Venkatesh, 2012). A smartphone, which has additional facilities such as, connecting older adults with friends and family, playing music, watching videos, and surfing on the internet, brings enjoyment for older adults. The role of perceived enjoyment has been studied in some studies in the literature such as, Davis et al. (1992), Verkasato (2010), Nimrod (2011), Song and Han (2009), Verkasalo et al. (2010) and Shin (2007). In order to test the significance of perceived enjoyment on the adoption of older adults, we test the following hypothesis.

H7: Perceived enjoyment has a positive influence on the behavioural intention of smartphone adoption within older adults.

2.2.8. Behavioural Intention/ Use Behaviour

The final factor drawn from the UTAUT (Verkatesh Venkatesh, 2012) is behavioural intention, which is the level to which a person has formulated a conscious plan to further use a device in the future. It is also the middle factor between the dependent variables and use behaviour.

In this study, behavioural intention is considered to influence further or continuous use of smartphones. We believe that with appropriate time and environments older adults can learn how to use smartphones (Chaffin and Harlow, 2005) as well as to learn from the younger generations. Some previous research

studies based on UTAUT showed the strong relationship between the dependent variables and behavioural intention such as the study of information technology in six organizations by Venkatesh et al. (2003), the use of an IT based, mobile application for Tuberculosis treatment (Seethamraju et al, 2018) and, mobile advertising by He and Lu (2007). In this study, the following hypothesis is proposed.

H8: Behavioural intention has a positive influence on the smartphone usage of older adults.

This research also identified moderator variables such as gender, age, experience and voluntariness of using smartphones (Venkatesh, 2012). Adding variables can increase the number of hypotheses to be studied, so our research focused on three of the main moderator variables; namely gender, age and experience (Nysveen et al., 2005).

As our research focused on general users where the users have a freedom to use or not to use their smartphones, the voluntariness of use was omitted. Figure 1 shows the different factors in our study and their relationships.

Place Figure 1 here

3. Research Methodology

3.1. Data Collection and Questionnaire Design

To gather the data needed for our study, an online questionnaire survey was developed and posted on the website www.surveymonkey.com. Along with the survey, an invitation letter was posted that preceded the questionnaire where the ethics number assigned to this research study by the academic institution was provided. The invitation letter also sought the participants' consent for participation and assured them of the research confidentiality. To ensure the validity of questionnaire contents, our study drew its questions from the literature and customised them to fit our study of using smartphones among older adults in north London. The questionnaire contained two sections. The first section examined the demographics and background information of the participants. This was a drop down menu for the ages, educational qualification, brands of smartphones, occupations and the vicinities based questions. The second part sought to ascertain whether respondents did use or did not use smartphones. Questions were developed in terms of those who smartphone users are (questions were based on constructs that were formed from the literature and shown in Table 2); not intending to be smartphone users or those who intended to adopt smartphones. To ascertain the users views a Likert scale ranging from 1 (Strongly disagree) to 7 (Strongly agree) was used.

The constructed questions were designed based on the studies by Venkatesh et al. (2012), Verkasalo et al. (2010), Park and Chen (2007I), Karjaluoto et al. (2010), Gu et al. (2009), Shin (2007) and Zhou et al. (2010). To obtain a UK perspective, household residents from North London were used. This area was specifically selected due to its current contributions to the economic growth in the UK[1] and its numbers of older adults that are shown in Table 1. The older adult population and the total populations of the sub-areas considered in our research are presented in Table 1. Figure 5 also illustrates the locations of vicinities considered in our study.

[1] In 2014, London's GVA (which is in place of the Gross Domestic Product (GDP) when considering local areas) of £364 billion accounted for 22.9% of the UK GVA (£1,590 billion), with the South East contributing a further 15.1%. Further, London saw the highest annual growth in 2014 of 6.8%, compared with the UK figure of 4.4% (Harari, 2016). In terms of older adults contributions, the 2013 GLA report 'The Economic Contribution of Older Londoners' found that the paid work of those aged 50+ in London contributed £47billion annually to London's economy, which is a huge contribution to the capital. It also stated that Londoners aged 65+ contributed £6.3 billion annually to London's economy through paid work, volunteering, as carers and looking after grandchildren.

Place Table 1 here

Place Figure 5 here

For the data collection sampling, a two-phase multi-stage random procedure was employed, which allowed an elimination of coverage errors and assigned an equal probability of selection for the areas and the households within the areas. The first phase comprised of stratifying the north London area into its towns and areas and phase two pertained to the household selection. For participation, the invitation letters in the survey flyer invited only older adults that were defined in the survey flyer and households were identified based on their addresses. There were no incentives of any kind to the participants, but they were informed that after the study was completed, the findings would be shared with them, which was done after the study period. Google Maps was used to identify the geographic starting point for flyers distribution. Therefore, due to the limitation of accessing the lists of all individual cases, and the area of north London being a large area for the researchers to cover, the cluster sampling technique was pursued. Along with the cluster sampling technique and in order to increase the sample size number, a link to the online questionnaire was sent as an email to a list of acquaintances as a starting point for a snowball sampling method. Overall, a total of 19,760 letters were distributed. Moreover, the online survey questionnaire, which was administered between November 2013 and February 2014, led to the receipt of 1,030 incomplete and 984 complete responses from older adults. The sample size of a PLS-SEM study should be at least ten times the largest number of structural paths directed at a latent construct in the structural model (Hair et al., 2016) which holds true for our study. Since SEM is sensitive to missing data and outliers, we examined the dataset to detect any irrelevant, incomplete or inaccurate data through cross-tabulation and finding summary statistics for each variable. Results showed that only three responses had missing data and the researchers decided to use a likewise deletion method by removing those cases from the analysis with at least one missing value. As the number of these cases is negligible considering the sample size, this did not affect the validity of the study.

3.2. Data Analysis

To statistically analyse the data, the Partial Least Squares-Structural Equation Modelling (PLS-SEM) approach was employed, which is able to provide more robust estimations of the structural model compared to the covariance-based models. “Structural Equation Modelling (SEM) is a powerful multivariate statistical technique which is a combination of factor analysis and multiple regression to examine the structural relationships among a set of measured and latent variables. The objectives of SEM are twofold as understanding the pattern and strength of correlations/covariances between variables, and accounting for the variance. Similar to traditional statistical methods, its results are sensitive to missing data, outliers and sample size. However, due to its flexibility and strength to deal with interrelated dependencies, SEM has been a popular tool in various applications including education (Tóth-Király et al., 2016), banking (Sharma, 2017) and healthcare (Mitchell et al., 2017) among others. In a nutshell, a structural equation model is composed of a set of two types of latent constructs called endogenous and exogeneous. While endogenous constructs can be thought of as dependent variables with at least one arrow pointing at them in the graphical representation of the model, exogenous constructs are independent variables. It should be noted that a variable can be independent in an equation and dependent in another (like behavioural intention in our model). SEM is

composed of two stages called measurement model and structural model. While in the measurement model, the measured variables are linked to latent constructs, the structural model connects the latent constructs to one another. Explaining SEM and its details is beyond the scope of this paper and interested readers can refer to Hair et al. (2016) for further information about SEM and its details."

PLS-SEM was viewed to be the appropriate tool in our study considering the objective of the study, which was theory development (Hair et al., 2011). Moreover, PLS-SEM has several advantages over covariance-based SEM methods such as, its ability to deal with small sample sizes and working with non-normal data. We used the SmartPLS 2.0 M3 software that is appropriate to explain complicated variable relationships among hierarchical structural models (Gefan et al., 2000). Following data cleaning, SEM was used for validity and reliability. PLS is effective for explaining both response and predictor variation (Chin, 1998) and for analysing more complex models by imposing less stringent assumptions on residual distributions and sample size. Additionally, PLS avoids two serious problems of inadmissible solutions and factor indeterminacy (Fornell and Bookstein, 1981). For the analysis, we used a two-step approach by first assessing the measurement model and then examining the structural model. Table 2 shows the constructs of our study and their abbreviated version used in the following tables.

Place Table 2 here

4. Research Findings

The responses revealed that 702 respondents had adopted smartphones, 134 respondents planned to have smartphones, and 148 respondents did not plan to have smartphones. 52.24% of the responses were provided by males, while 47.76% were from female respondents. A large number of the respondents (56 %) were from the 50-59 age group, 34.45% from the 60-69 age groups, 7.52% was from the 70-79 age groups, 1.63% was from the 80-89 age groups, and 0.2% was from the over 90 years old. In the group of adopters, the majority (64.10%) was from the 50-59 age groups and 30% was from the 60-69 age groups. However, a majority (49.32%) of the respondents not planning to have a smartphone was from the 60-69 age group. Moreover, the number of respondents in the 60-69 age planning to have a smartphone was larger than the adopted groups. With regards to employment status, 32.83% of respondents were in full-time employment, 19.61% of the respondents were pensioners (65+) and 12.60% were self-employed respondents. Both the retired (over 65 years old) and part-time employed respondents were at 10.87% equally. 6.5% of the respondents were unemployed, 3.15% were entrepreneurs, 1.12% were disabled, and 0.81% were housewives. Table 3 includes details of the participants' socio-demographics.

Place Table 3 here

4.1. Use of Smartphones

As the usage of smartphones was also of interest in this research, a question on smartphone usage was included. For this, 15 questions on smartphone features were solicited usinga Likert scale ranging from 1 to 7, where one represents "never" and seven means "many times per day".

In Table 4 the first column states the application of smartphones, while the second column is the average score given in the Likert scale. The third column shows the number of people who replied to the Likert scale in terms of the features that they used on their smartphone. From this column, people tended to send SMS more frequently than making a phone call. For advanced features, 89.60% of the replies indicated that the phone was used for browsing, and 85.47% of the respondents used their

phone's email features. Mapping or Navigator were used 78.77% with a 3.21 frequency. Managing appointments and calendars was used by 72.36% with 3.52 frequencies. Reading online news or magazines was used by 68.66% with 3.15 frequencies. Taking notes, filming a video, using social networks such as Facebook, watching videos and playing games were used by more than half of the users. The frequency of using social media was the highest in this group at 3.26. There was also a question seeking information about Voice over Internet Protocol (VoIP) usage, or video calling applications such as Facetime, Skype, or Viber, followed by using smartphones to contact government authorities such as NHS or Job centre plus that showed a low frequency with results at 2.22 and 1.80 respectively.

Place Table 4 here

4.2. Analysis of the Adoption of Smartphones

4.2.1. Measurement Model Assessment

For the measurement model, validation tests of the constructs were conducted using construct validation and factor analysis. To test for construct validity, evidence of convergent and discriminant validity was demonstrated, which is a requirement when construct validity is conducted. In order to assess the convergent utility of the constructs, the Average Variance Extracted (AVE) measure was used. As seen in Table 5, the minimum AVE value is 0.74, satisfying the recommended threshold of 0.5 by Fornell and Larcker (1981). Following construct validity, reliability needed to be determined. Reliability is defined as the reproducibility or stability of data and observations. In Table 5, it can be seen that the loading factors of items FC4, SOC3 and SOC4 were less than 0.8, although this researcher does acknowledge that the results should be higher than 0.7. Due to the previously mentioned items being less than 0.8 there were removed and only the significant indicators were kept.

Place Table 5 here

Focusing first on our measurement model, reliability measurements show that most of our constructs scored well above the threshold values across all indices. Specifically, all the constructs performed well except for resource FCs. Furthermore, Average Variance Extracted (AVE) indicates the variance a construct captures from its indicators, relative to the variance contained in measurement error, as an indicator, is generally interpreted as a measure of reliability for a construct (Hair et al., 2011). In our study, all the AVEs for the constructs are above the 0.7 cut-off value. Hence, we can conclude that the measurement has both internal consistency and convergent validity.

Following the findings, analysis was conducted that led to obtaining 24 observed items over nine latent constructs. After the first analysis, some observed items with loading factors below 0.7 were removed (SOC4 and FC4) as given in Table (6). Composite reliability (CR), which measures the internal consistency exceeds the 0.7 threshold for all constructs; thus ensuring their reliability. Furthermore, all the constructs' AVE were above 0.5. Finally, according to Fornell and Larcker (1981), when identifying discriminant validity, the square root of AVE for all the constructs needs to exceed all the other cross-correlations. This criterion was also satisfied for the overall constructs. As such, the model also exhibited satisfactory discriminant validity.

Place Table 6 here

4.2.2. Structural Model Assessment

Following the measurement model assessment, the conceptual framework of this study had to be empirically operated. SEM was applied that led to a situation where statistical significances of path coefficients (*p*-value) were observed. Results of running the test showed that the model could explain almost 76% of the older adults' intention to use smartphones and 20.78% of the older adults' actual use of smartphones. Although unanimous agreement does not exist on how to interpret the R-squared values in the literature, values above 0.7 are generally considered as significant. In this paper, we use the ranges given by Hair et al. (2011) in which the values of 0.75, 0.50 and 0.25 are described as substantial, moderate or weak, respectively. Hence, in this research the R-square of 75.96% was substantial for the intention to use smartphones. However, for actual use, the R-squared was 20.78%, which can be considered as weak. Nonetheless, when comparing smartphone use in terms of consumer behaviour, an R-square of 20.78% can be considered as significant (Hair et al., 2011). The path coefficients (β) and *t*-values from the bootstrap and PLS algorithm were also applied to explain the results. From this, perceived enjoyment (H7) had the strongest factor influence of behavioural intention to use smartphones within the older adults with β=0.380, *t*-value=13.3 and a significant level of (*p*)<0.001. Performance expectancy (H5) is a strong factor with $p<0.001$as given in table (7). Facilitating Conditions (H4) and Effort Expectancy (H6) were considered significant with $p<0.01$.. Importantly, the behavioural intention for the overall sample population appears to have an important effect on actual use (*t*-value=13.5 and $p<0.001$) However, Observability (H1), Compatibility (H2), and social influence (H3) were considered as not significant with *p*-values of 0.609, 7.139, and 0.240 respectively. Therefore, of the eight hypotheses formed for this research study, six were supported as shown in Table (7) and illustrated in Figure (2) below.

Place Table 7 here

Place Figure 2 here

To prevent any bias to this research, and to ascertain whether there could be some identification of specific groups to the factors of adoption, use and diffusion, we analysed the findings by undertaking an additional set of analysis for two age groups: the 50-59 and 60-69 years old age groups. Then, we compared the results with the findings for the overall sample as given in table (8). These age groups were selected as they are the age groups that provided answers allowing some analysis to be undertaken.

The results showed that there is complete similarity between the 50-59 age group and the overall sample in terms of the factors affecting the adoption and use of smartphones. The facilitating conditions (H4) and effort expectancy (H6) did not have significant effects at a five-percent level for the 60-69 years old, which suggested that the 60-69 years old do not have the necessary resources and do not find it easy to use and adopt smartphones.

Place Table 8 here

Place Figure 3 here

Place Figure 4 here

A factor that also emerged in demographic and older adults studies is the role of learning that we identified for this study as education. This is also viewed as an important pathway of improving older adults' quality of life in many countries (Yin, 2011). Many studies show that older adults are increasingly engaged in both formal and informal educational programs (Danner, Danner, & Kuder,1993; Pearce, 1991). Recognising this as an important factor of consideration, we carried out

two separate analyses on respondents with a higher education degree and those with no higher education degree in the overall older adult population where the results are shown in Table 9. The findings revealed that the factors influencing the adoption and use of smartphones in the cohort with no higher education degree are: Compatibility (H2) and Effort Expectancy (H6). What was also realised is that they are not significant factors influencing the adoption and use of smartphones for the cohort with a higher education degree. Therefore, the devices being applicable, suitable or more attuned to individuals' daily lives and efforts are not important for those with higher education degrees. However, Facilitating Conditions (H4) and Perceived Enjoyment (H7) are marginally significant for the higher education individuals, but strongly significant for those with no higher education. Therefore, for those with no higher education degree, the resources and enjoyment, which suggests a stimulating, but informative environment draw the older adults with no higher education to adopt the devices more than those with a higher education degree.

Having provided an explanation of the analysis and findings, the next section provides a discussion of these results and places the results of this study in terms of previous studies in order to identify its novelty and similarities.

4.3. Analysing the adoption results in terms of the moderator variables

As this study is considering older adults, age was a major factor of consideration for this study; however, it was also mentioned that there are more moderator variables drawn from the original UTAUT so that there can be an increased understanding of the research contributions of this study. From UTAUT, it was learnt that moderator variables affect relationships between the independent and the dependent variables (Venkatesh et al., 2003).

The original moderator variables drawn from UTAUT are gender, age, experience, and voluntariness of use. Experience in this study is defined as the experience of using smartphones. Moreover, since this research is related to older adults, health is selected as a moderator variable. Education is also often used as a moderator variable in technology adoption research (Park et al, 2007); hence also considered by this study. This study also examined five moderator variables that are gender, age, experience, health, and education with the supported hypothesis (Dabholkar & Bagozzi, 2002; Park et al., 2007).

The data was analyzed using the process of Lowry and Gaskin (2014) and a formula provided by Chin (2000). The process began by dividing the main data into two groups, but dependent on the moderators. For gender, the dataset was divided into male and female. For age, the dataset was separated between 50-59 and 60-79. The users experience was divided to under 2 years and more than 2 years of using smartphones. Health is a self-assessment where three choices were available for participants: poor, good and excellent. For moderator analysis, the good and excellent expressions were grouped against poor. The utilized education levels were Higher Degree, and First Degree against High Diploma, Diploma, A level, and O level. The sub-groups were then analyzed using R and Chin's (2000) formula to find *t*-values or significant values. Only the significant results are shown in Table 9.

Place Table 9 here

The results of the moderated variables disclosed that education moderated the relationship between FC and INT while experience moderated the link between INT and ACU significantly ($p<0.05$). This meant that the effect of facilitating conditions was stronger for those with higher education. It can also be implied that for higher education individuals, there are more resources such as time, money, and knowledge to use their smartphones. It was also discovered that the effect of intention to continue using smartphones will be stronger for those who are more experienced at adopting and using their

smartphones. This finding suggested that the more experienced individuals (more than two years) will spend increasing times on their smartphones. Other moderator variables that were almost significant (p<0.15) were Age that provided the link between ENJ and INT; Health and education between INT and ACU. The implications of these results are that individuals with higher education and good health are likely to use smartphones more than those who have health problems and lower education. Further, the effect of perceived enjoyment will be stronger for those adults who are 60 years old and above. Tables (10) and (11) provide a summary of the results for the moderating variables.

Place Table 10 here

Place Table 11 here

5. Discussion

In this paper, building upon previous theories that have been used to examine adoption generally and an online survey questionnaire, an investigation of a social change in the form of smartphones within the older adult population was completed.

Our findings illustrate that an older population adopts smartphones more for perceived enjoyment, which was also found in previous mobile and not smartphone research in leading internet infrastructure development countries such as South Korea (Shin 2007); 3G mobile technology in China (Song and Han, 2009); mobile applications in Finland (Verkasalo et al., 2010), and in Canada and France on mobile devices used for surfing the internet (Saber and Souiden, 2010). However, the word 'enjoy' or 'fun' can be interpreted differently within older adults. That is, older adults may not consider action games as enjoyable, but may consider using their smartphone for capturing or recording their moments to share with friends or family as enjoyment or fun, or for a purpose. These memories captured within smartphones can also assist in memory recall when considering ways of reducing, or slowing age-related diseases such as, Alzheimers (Bosco and Lancioni, 2015), and depression (Cotten et al., 2012). This also demonstrates that the smartphone is not only a device for enjoyment, but has a function or purpose, which aligns with Kim and Hwang's findings (2012). This also relates to the issue of social inclusion as smartphones are ensuring that individuals' age-related diseases are reduced or eliminated. Therefore, smartphone and network providers may need to consider such factors when increasing smartphone adoption within older adults. That is, smart phones could provide more of an element associated with features that allow recording and capturing data and moments rather than internet, online based games aspect. In turn this can help with providing "photographs as aids to reconstructing and recollecting past events and experiences (Redfoot & Back, 1988; Sherman, 1991; Wapner et al, 1990). Perceived enjoyment also appeared in the segmented results for those individuals with no higher education degrees; thus supporting the assertion that this is an important factor of consideration. In academic terms these results confirmed that for smartphones or new technology adoption, enjoyment is one of the important factors of consideration, but the feature of photograph sharing and viewing offers potential in providing cues for memory recall and the management and stabilisation of chronic diseases such as, Dementia.

Hypothesis (4) ascertained whether facilitating conditions influence older adults' intention for adopting smartphones. It was found that it was true in the case of this study, as was found in the instance of previous studies of generally mobile internet usage (Venkatesh et al., 2012). From the responses, it was realised that older adults want to know more about how to use smartphones and rarely had someone to assist them. This also aligns with previous research that identified issues associated with complexities as having no one to seek information and knowledge about the devices (Lee et al., 2011). The factor of

facilitating conditions also emerged when the age groups were segmented into different age groups of 50-59 and 60-69 and those with higher and no higher degree. This means that smart phone and internet service providers should consider having an individual or department offering information or knowledge for using and adopting smartphones, which will encourage more older adult individuals to adopt and use smartphones; thereby, increasing the sales of these phones.

A solution to the issue of complications can be determined from the responses to the questions on effort expectancy (H6) with mean values of 5.67 and 5.54 with 1.41 and 1.46 standard deviation that suggested older adults view smartphones as devices that are easy to use. This was further confirmed by this study when the category of higher education and no higher education was formed where it became apparent that effort expectancy was significant and important for those with no higher degree. This also aligns with Hardill and Olphert (2012) results that identified that mobile phones have been gradually integrated some of the lives of older adults. Thus, policy makers, smartphone providers, and software developers will need to place an emphasis on providing not only easy to use devices but also easy to understand demonstrations and assistance. For businesses, this implies an opportunity as videos and call centers catering to the needs and requirements of older adults will need to be developed that cater to the needs and requirements of older adult consumers. This implies employment for individuals focused upon older adult consumers and the building of more knowledge within society of the factors that will encourage older adult consumers' attitudes to change favourably towards using the smartphone and the internet.

In terms of smartphone usage, the older adults' behaviour suggests that they used only the basic features of a smartphone, such as making a phone call or sending a message. However, new features for smartphones such as, emailing and browsing were also used with a high frequency. This suggests that older adults are very proficient in smartphones uses and do accept advanced features of mobile devices. This implies that marketing organizations seeking to build long term, profitable relationships with diverse consumers can build advertising strategies that can be in the form of emails or google advertisements that use the internet. This aligns with the view expressed by Porter and Donthu (2006) who suggested that "development of segment-specific strategies also align with a firm's internal capabilities". Further, our findings showed that the less adopted features of a smartphone were managing appointments on calendars or taking notes. A feature not popular within the older adults was watching videos on smartphones, which the research team attributed to the smartphone screen sizes. This issue was a matter of concern as pointed by more than half of the responses. In some cases, older adults have physical limitations such as, problems related with the vision or cognition. Therefore, large screen size smartphones may be more compatible with older adults.

6. Conclusion, Implications, Limitations and avenues for future research

Older adult consumers are increasing in the present times, which suggests that businesses need to cater to this demographic group of society's needs and requirements. To inform business, academia and policy makers, this research aimed to study the adoption, usage and diffusion of smartphones within UK's older adult population. To investigate the adoption, a research model, the Model of Smartphone Acceptance (MOSA) was developed based on the UTAUT, DoI and perceived enjoyment from TAM 3. From an online questionnaire survey, our study received 984 complete and usable responses. Of these, 702 respondents had adopted smartphones, 134 planned to have one, and 148 did not adopt and did not plan to have one. This also suggests that the older consumer is not being socially excluded by adopting, using and diffusing smartphones, which, in turn affects wellbeing and happiness (Dennis et al, 2016). The results also revealed that 76% of the behavioural intention construct to use smartphones could be

explained in the conceptual framework. Additionally, perceived enjoyment was the strongest factor influencing behavioural intention. Significant factors in the conceptual model were performance expectancy, compatibility, facilitating conditions, and effort expectancy. Education was a moderator variable in the link between facilitating conditions and behavioural intention, while experience of using smartphones moderated the affect between behavioural intention and the actual use of smartphones. However, social influence and observability were not significant for this research.

The implication of this research study to the literature for older adults' adoption, use and diffusion of smartphones is the provision of a research model specifically for older adults in the context of smartphones. Although there have been studies of older adults and educated individuals using an extended TAM, the study was on attitudes to technology (Porter and Donthu, 2006). Our study differs to such studies as we used mobile devices and we narrowed it to a demographic group as we could understand factors specific to the demographic group rather than to generalise and further segment the population. Therefore, we identified factors specific to a group that will influence their attitudes and behaviours to accepting and using smartphones. Further, in consumer perspective studies older adults are viewed to be resistant to new technologies, but although not generalizable, our studies suggest that older adults are open to adopting, using and diffusing new technologies. Using studies as ours, the challenges that older adult consumers and the population generally face could be reduced or eliminated. Moreover, this research highlights strengths and weaknesses for the adoption, use and diffusion of smartphones, which could be used to promote an increase in sales within the older adults. For industry, the implication of this research is the identification of factors that should lead to an increase in adoption, use and diffusion of smartphones within older adults. Older adults are an important socio-demographic society in current times, not only as consumers, but as employers and employees, which implies that such research should provide a substantial contribution to research and society as well as organizations. For future studies, a reference point that can lead to the adoption, use and diffusion of smartphones has been formed, which was less evident before. Previous studies such as, Porter and Donthu (2012), and Dennis et al. (2016) have identified and suggested that these age groups are of consideration, but this study extends and enhances that view by considering only the older adult population and their attitudes towards adopting, using and diffusing smartphones. In terms of specific factors, we identified the factor Facilitating condition being critical for the wider adoption, use and diffusion of smartphones. This was also identified in the structural model and by segmenting the sample population. For industry, the implication of this research is the identification and reference to factors that could lead to an increase in sales of smartphones in the future. For instance, the emergence of older adults finding the screen size as a problem that discourages viewing of entertainment programmes provides an incentive to manufacturers of smartphones to search for better solutions to such a problem. This study is also beneficial as it suggests that an age group that was viewed to be resistant to change is adopting, using and diffusing newer forms of ICT, which is encouraging for the manufacturers of mobile devices per se, but we have tried to show the factors that will assist industry service providers to increase sales of smartphones within the older adults consumer market.

As with all research studies, this research also has some limitations. Due to the application of quantitative research, it may not capture additional views apart from the proposed factors. To further generalise this study, future studies should verify the research framework's application by seeking to increase the respondents' numbers. A deeper perspective may also be obtained by utilising a qualitative approach such as, interviews, ethnography, or focus groups, which we could not conduct as it would have led to a deviation of our research aim. Our research currently focused on mainly adoption theories; therefore, the theories related to usage were not included. Therefore, in the future other

perspectives could provide a diverse perspective to this research by considering other issues associated with adoption and use and combining the aspects to form a more detailed future conceptual model. Moreover, this research also realised the difference in terms of cultures; thus, the results may only be used as guideline in difference cultures or geographical areas. A diverse aspect taken in this research is to apply a rough way of segmenting the demographic group. We recognise that this poses to be a limitation in this study; therefore, a future study will apply weighting criteria to ensure that the statistical verification and validity criterion is also met. However, as we mentioned, few studies of older adult consumers and their adoption, use and diffusion of smartphones per say have been undertaken and that is where we foresaw our contribution emerging. Finally, smartphones are used in various ways of daily life including for online shopping, online banking and online health services. When using these services, the roles of trust and risk are pertinent, which previous research has found is important (Chang et al, 2016). Therefore, a future study should identify whether the role of trust and risk is important in the UK as in other countries. Moreover, one can consider carrying out a similar research with different age groups to see if the same results are obtained. We believe that a definition of age groups will be a complex part of that research and will need a sound validation.

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Table 1. Population of north London areas (Office of National Statistics, 2011)

Area	Population	50+ Population	Percentage
Barnet	356,386	102,741	28.83%
Brent	311,215	77,860	25.02%
Camden	220,338	53,552	24.30%
Enfield	312,466	86,442	27.66%
Haringey	254,926	55,641	21.83%
Islington	206,125	43,338	21.03%
Westminster	219,396	55,299	25.21%
Total	1,880,852	474,873	25.25%

Note: London Population was at 8.83 million in 2016 (Source: CBRE, 2016)

Figure 5: The Map of London and the vicinities covered in our study

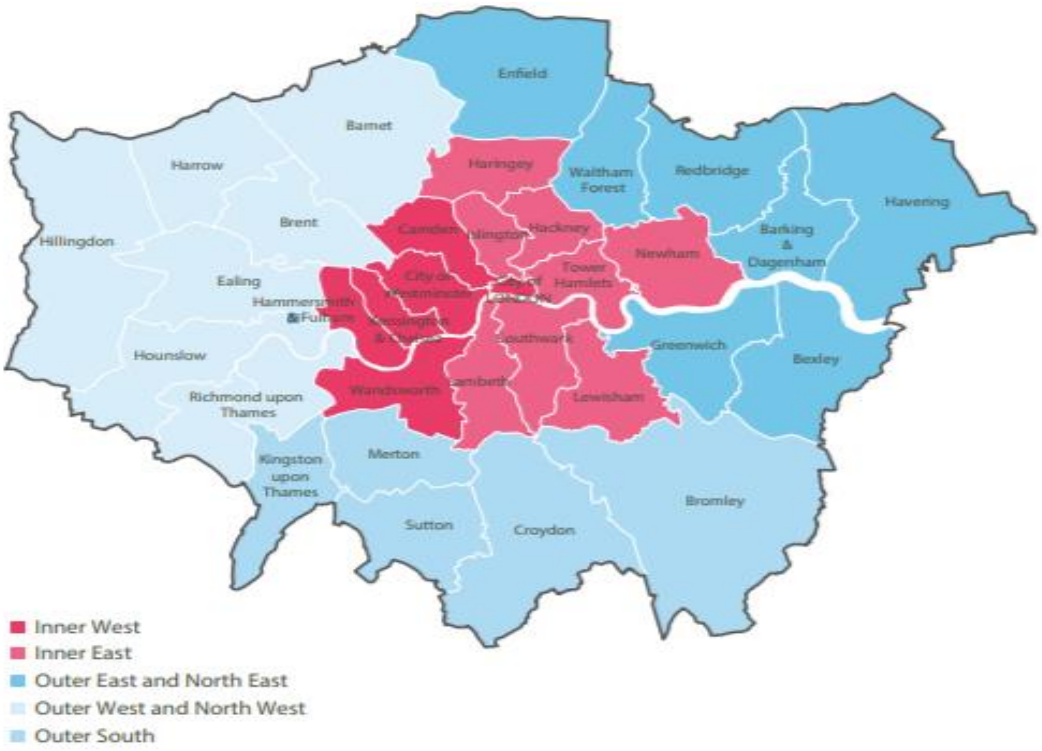
Enfield
Barnet
Harrow
Haringey
Waltham Forest
Redbridge
Havering
Brent
Hillingdon
Camden
Islington
Hackney
Barking & Dagenham
Newham
Tower Hamlets
Ealing
City of Westminster
City of London
Hammersmith & Fulham
Kensington & Chelsea
Southwark
Greenwich
Bexley
Hounslow
Wandsworth
Lambeth
Lewisham
Richmond upon Thames
Kingston upon Thames
Merton
Bromley
Sutton
Croydon
Inner West
Inner East
Outer East and North East
Outer West and North West
Outer South

Table 2. Constructs of our study

Construct	Measure	Source
Behavioural Intention (IN)	I intend to continue using mobile Internet in the future I will always try to use mobile internet in my daily life I plan to continue to use mobile internet frequently	Venkatesh et al. (2012)
	Whenever possible, I intend to use smartphone in my job I intend to increase my use of smartphone in the future	Park and Chen (2007)
Social Influence (SOC)	People important to me think I should use service (climate for networking) It is expected that people like me use service (nationalistic feelings)	Shin (2007)
	People who influence my behaviour think that I should use mobile internet	Venkatesh et al. (2012)
	I want to use the service because my friends do so, and I want to belong to the group	Verkasalo et al (2010)
Observability (OB)	It is easy for me to observe others using the smartphone in my work I have had a lot of opportunity to see the smartphone being used	Park and Chen (2007)
Compatibility (COM)	I believe that using mobile banking will fit my lifestyle I believe that using mobile banking is suitable for me	Karjaluoto and Koening-Lewis (2010)
	Using the smartphone fits into my work style I think that using the smartphone fits well with the way I like to work	Park and Chen (2007)
Facilitating Conditions (FC)	I have the resource necessary to use mobile internet I have the knowledge necessary to use mobile internet	Venkatesh et al. (2012)
	Operating costs do not prevent the use of smartphones	Venkatesh et al. (2012)
	I have the person available for assistance with mobile banking use	Gu et al. (2009)
Performance Expectancy (PE)	I feel mobile banking is useful Mobile banking lets me make payments more quickly	Zhou et al (2010)
	Using mobile internet increases my productivity Using mobile internet helps me accomplish things more quickly	Venkatesh et al. (2012)
Effort Expectancy (EE)	I find that using mobile banking is easy Learning how to use mobile banking is easy for me	Zhou et al (2010)
	I find mobile internet easy for me Learning how to use mobile internet is easy for me	Venkatesh et al. (2012)
Enjoyment (ENJ)	I think it is fun to use the service (mobile services)	Verkasalo et al (2010)
	I find service fun	Shin et al. (2007)

Table 3. The socio-demographics of the participants

Category	Adopted		Plan to Have		No plan to have		Total	
	Respondents	%	Respondents	%	Respondents	%	Respondents	%
Gender								
Male	382	54.42%	59	44.03%	73	49.32%	514	52.24%
Female	320	45.58%	75	55.97%	75	50.68%	470	47.76%
Total	**702**	**134**	**148**	**984**				
Age								
50-59	450	64.10%	64	47.76%	39	26.35%	553	56.20%
60-69	211	30.06%	55	41.04%	73	49.32%	339	34.45%
70-79	39	5.56%	12	8.96%	23	15.54%	74	7.52%
80-89	2	0.28%	3	2.24%	11	7.43%	16	1.63%
90+	0	0.00%	0	0.00%	2	1.35%	2	0.20%
Total	**702**	**134**	**148**	**984**				
Education								
Higher degree PG	95	13.53%	11	8.21%	12	8.11%	118	11.99%
1st Degree	187	26.64%	41	30.60%	42	28.38%	270	27.44%
HND/HNC/Teaching	48	6.84%	9	6.72%	14	9.46%	71	7.22%
A-Level	104	14.81%	21	15.67%	27	18.24%	152	15.45%
BTEC/College Diploma	77	10.97%	9	6.72%	14	9.46%	100	10.16%
GCSE/O-Level	176	25.07%	41	30.60%	37	25.00%	254	25.81%
Others	15	2.14%	2	1.49%	2	1.35%	19	1.93%
Total	**702**	**134**	**148**	**984**				
Area								
Barnet	95	13.53%	12	8.96%	25	16.89%	132	13.41%
Brent	42	5.98%	11	8.21%	8	5.41%	61	6.20%
Camden	158	22.51%	35	26.12%	42	28.38%	235	23.88%
Enfield	99	14.10%	25	18.66%	22	14.86%	146	14.84%
Haringey	108	15.38%	19	14.18%	22	14.86%	149	15.14%
Islington	90	12.82%	12	8.96%	16	10.81%	118	11.99%
Westminster	110	15.67%	20	14.93%	13	8.78%	143	14.53%
Total	**702**	**134**	**148**	**984**				

Table 4. Smartphone usage

Feature of smartphone	Average	Number	Percent
SMS, Text messaging	5.19	689	98.15%
Making a phone call	4.76	687	97.86%
Taking a photo	3.58	647	92.17%
Browsing/surfing website(s)	4.35	629	89.60%
Emailing	4.19	600	85.47%
Mapping, navigator such as Google Map, Tom-Tom, etc.	3.21	553	78.77%
Managing my appointment on my calendar	3.52	508	72.36%

Reading online news and online magazines	3.15	482	68.66%
Taking noted such as shopping lists or tasks that I need to do	2.95	472	67.24%
Filming a video	2.37	454	64.67%
Using social network such as Facebook, Twitter	3.26	440	62.68%
Watching videos	2.45	426	60.68%
Playing games	2.89	420	59.83%
Using Facetime, Skype, Oovoo, Google Talk, Viber, Fring	2.22	322	45.87%
Using to contact government authorities such as NHS, UKBA, etc.	1.80	243	34.62%

Table 5. Cross-correlations, item loadings, average variance extracted, composite reliability, *R*-square and Cronbach's Alpha of the model

	COM	EE	ENJ	FC	INT	OBS	PE	SOC	Item Loadings	AVE>0.50	CR>0.70	R-square	CA>0.70
COM	**0.94**								0.92-0.95	0.87	0.95		0.93
EE	0.61	**0.97**							0.96-0.97	0.93	0.97		0.93
ENJ	0.66	0.65	**0.98**						0.98-0.98	0.96	0.98		0.96
FC	0.73	0.66	0.54	**0.86**					0.84-0.88	0.74	0.90		0.83
INT	0.77	0.66	0.78	0.66	**0.88**				0.84-0.91	0.78	0.91	0.76	0.86
OBS	0.55	0.36	0.33	0.55	0.42	**0.95**			0.95-0.95	0.90	0.95		0.90
PE	0.75	0.57	0.61	0.61	0.74	0.43	**0.88**		0.85-0.90	0.77	0.91		0.85
SOC	0.53	0.28	0.4	0.4	0.43	0.46	0.51	**0.86**	0.82-0.88	0.74	0.89		0.82

Table 6. Factor Loading Table

	ACU	COM	EE	ENJ	FC	IN	OBS	PE	SOC
ACU	**1**	0.445	0.334	0.345	0.375	0.456	0.23	0.425	0.206
COM1	0.419	**0.921**	0.614	0.621	0.721	0.736	0.528	0.672	0.43
COM2	0.407	**0.954**	0.556	0.619	0.674	0.731	0.504	0.701	0.516
COM3	0.422	**0.93**	0.527	0.597	0.658	0.694	0.509	0.726	0.513
EE1	0.35	0.619	**0.969**	0.632	0.643	0.662	0.353	0.581	0.253
EE2	0.293	0.549	**0.964**	0.624	0.632	0.617	0.349	0.51	0.245
ENJ1	0.33	0.668	0.644	**0.982**	0.534	0.768	0.334	0.61	0.401
ENJ2	0.349	0.617	0.632	**0.981**	0.524	0.757	0.307	0.597	0.371
FC1	0.339	0.674	0.506	0.439	**0.888**	0.558	0.538	0.574	0.384
FC2	0.302	0.63	0.736	0.541	**0.852**	0.602	0.475	0.505	0.293
FC3	0.333	0.584	0.459	0.404	**0.846**	0.54	0.417	0.506	0.313
FC4	0.018	0.122	0.035	0.074	**0.117**	0.061	0.219	0.091	0.246
IN1	0.446	0.672	0.594	0.809	0.531	**0.9**	0.329	0.672	0.406
IN2	0.353	0.681	0.63	0.609	0.657	**0.844**	0.409	0.57	0.313
IN3	0.404	0.694	0.537	0.628	0.569	**0.908**	0.378	0.714	0.403
OB1	0.225	0.526	0.374	0.308	0.536	0.414	**0.955**	0.413	0.411
OB2	0.212	0.52	0.314	0.314	0.53	0.381	**0.947**	0.406	0.457
PE1	0.387	0.757	0.58	0.602	0.625	0.712	0.427	**0.85**	0.405
PE2	0.339	0.59	0.437	0.497	0.491	0.609	0.354	**0.895**	0.47
PE3	0.391	0.605	0.459	0.51	0.486	0.616	0.345	**0.894**	0.452
SOC1	0.14	0.434	0.211	0.367	0.309	0.362	0.361	0.396	**0.856**
SOC2	0.15	0.41	0.16	0.31	0.304	0.326	0.347	0.397	**0.871**
SOC3	0.23	0.501	0.325	0.337	0.425	0.404	0.449	0.494	**0.799**
SOC4	0.117	0.265	0.063	0.216	0.143	0.228	0.26	0.271	**0.649**

Table 7. Hypothesis, path coefficients, t-value, significance and hypothesis support

Index	Hypothesis	β	*t*-value	*p*-value	Supported?
1	Observability -> Behavioural intention	-0.013	-0.510	0.609	
2	Compatibility -> Behavioural intention	0.252	0.035	7.139	
3	Social influence -> Behavioural intention	-0.027	-1.175	0.240	
4	Facilitating conditions -> Behavioural intention	0.094	3.008	0.003	✓
5	Performance expectancy -> Behavioural intention	0.232	7.751	<0.001	✓
6	Effort expectancy -> Behavioural intention	0.086	2.995	0.003	✓
7	Perceived enjoyment -> Behavioural intention	0.372	13.292	<0.001	✓
8	Behavioural intention -> Smartphone usage	0.454	13.500	<0.001	✓

Table 8. Comparing the effects of age groups in terms of the factors of immense consideration

	Pr(>|t|)		
	50-59	60-69	Overall
SOC	0.51	0.14	0.24
OB	0.81	0.72	0.61
COM	**<0.001***	**<0.001**	**<0.001***
FC	**0.02***	0.19	**<0.001***
PE	**<0.001***	**<0.001***	**<0.001***
EE	**<0.001***	0.09	**<0.001***
ENJ	**<0.001***	**<0.001***	**<0.001***
BI	**<0.001***	**<0.001***	**<0.001***

* Significant at a five-percent level

Table 9. Comparing the effects of education

	Pr(>|t|)	
	Higher Education	No Higher Education
SOC	0.616	0.182
OB	0.818	0.779
COM	0.327	**<0.001***
FC	0.049	**<0.001***
PE	**<0.001***	**<0.001***
EE	00.418	**<0.001***
ENJ	**0.049***	**<0.001***
BI	**<0.001***	**<0.001***

* Significant at a five-percent level

Table 10. Moderating Model-Experience

	Less than two years (*n*=238)				More than two years (*n*=64)				Compare	
Hypothesis	*β*	*t*-value	Mean	STERR	*β*	*t*-value	Mean	STERR	*t*-value	*p*-value
INT -> ACU	0.525	9.342	0.523	0.0562	0.352	7.079	0.3502	0.0497	2.159	0.031

Table 11. Moderating Model-Education

	Low (*n*=405)				High (*n*=282)				Compare	
Hypothesis	*β*	*t*-value	Mean	STERR	*β*	*t*-value	Mean	STERR	*t*-value	*p*-value
FC ->INT	0.199	3.687	0.200	0.054	-0.088	1.329	-0.087	0.067	3.366	0.001
INT ->ACU	0.404	7.923	0.403	0.051	0.523	9.847	0.523	0.053	1.600	0.110

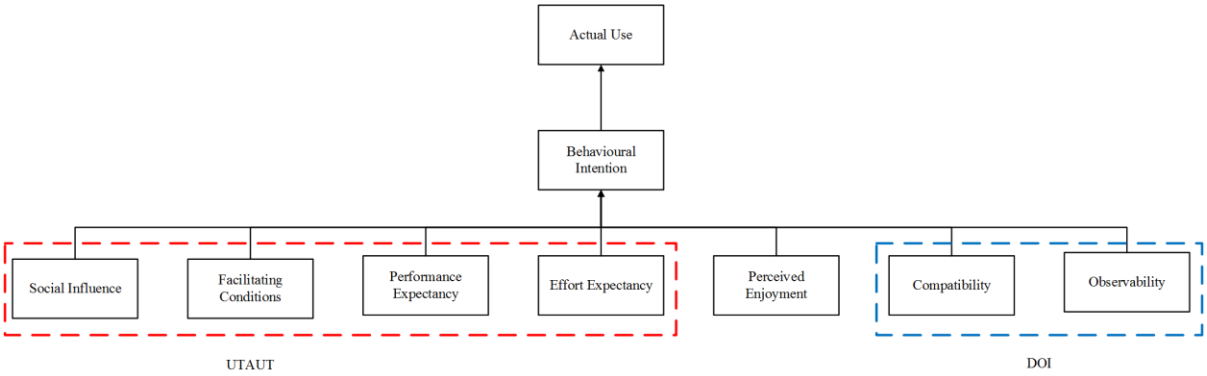

Figure 1: The model of smartphone acceptance

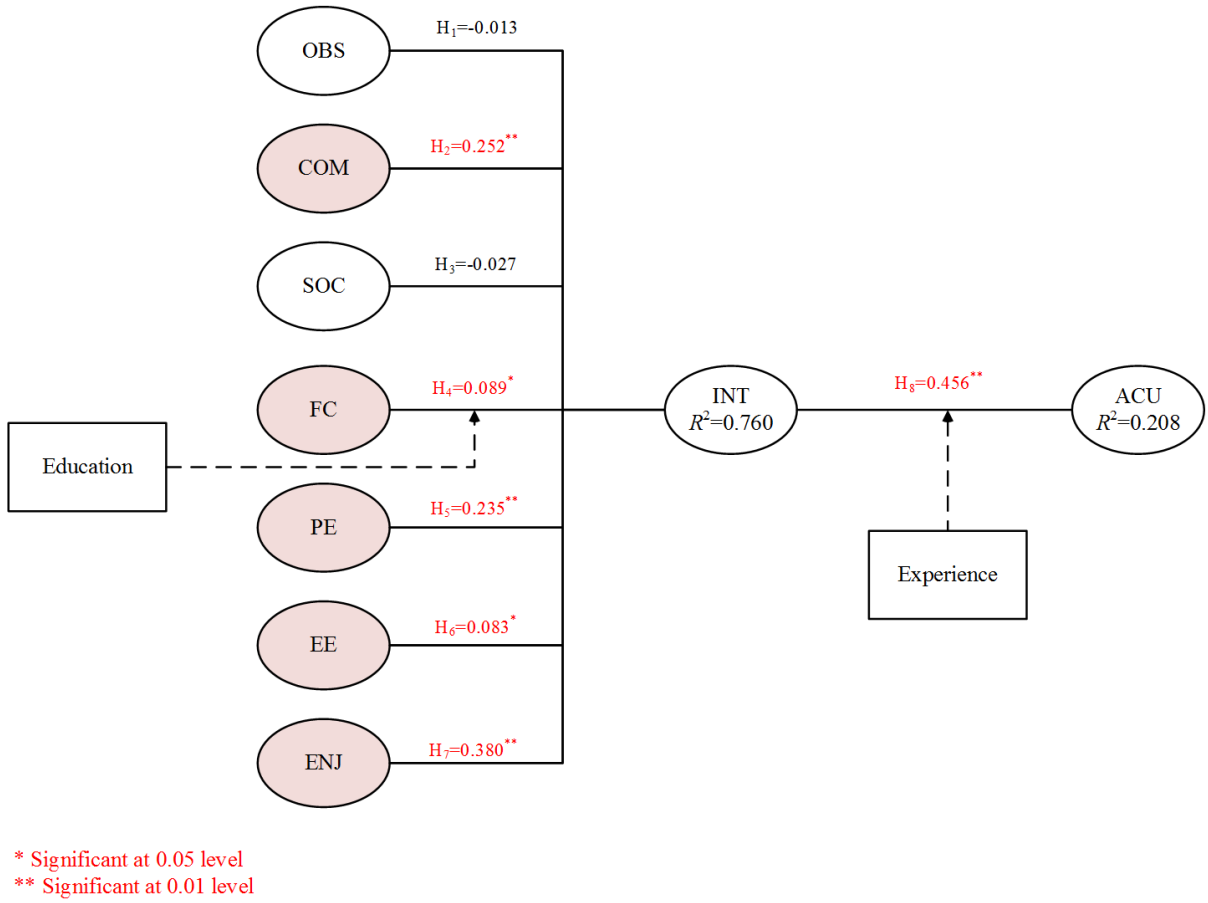

Figure 2. Relating the Hypothesis of this research model