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Festus Oluseyi Oderanti \*  
Hertfordshire Business School, de Havilland Campus,  
University of Hertfordshire, UK  
[F.Oderanti@Herts.ac.uk](mailto:F.Oderanti@Herts.ac.uk)

Feng Li,  
Cass Business School, City University,  
106 Bunhill Row, London, EC1Y 8TZ, London.  
[Feng.Li1@city.ac.uk](mailto:Feng.Li1@city.ac.uk)

### **Biographical Statements**

(1) Festus Oluseyi Oderanti is a Senior Lecturer in Information Systems at Hertfordshire University Business School, UK. Prior to that, he was a Lecturer in Knowledge and Information Management at Plymouth University Business School (7/2013-6/2016). He had also worked with Newcastle University Business School (2011-2013) as a Postdoctoral Research Fellow on a project under the ‘Assisted living: Economic and Business Models, and Social & Behavioural Studies’ programme, funded by TSB, ESRC & NIHR as part of Assisted Living Innovation Platform (ALIP). Before that, Festus had worked as IT Analyst with Information Services Division of the University of Edinburgh for more than three years. Also before he moved to the UK, he worked for five years with Osun State Polytechnic, Nigeria as a lecturer with Computer Science and Engineering Departments. Festus holds two Master degrees (Computer Science and Business Administration) and obtained his PhD in Computer Science from Heriot-Watt University, UK.

(2) Feng Li is the Associate Dean for Research & Enterprise and Professor of Information Management at Cass Business School, City University, London. Before that, Feng was Chair of e-Business Development for more than 10 years at Newcastle University Business School where he held various senior management responsibilities as a Member of School Executive Team, including Director of Business Engagement, Subject Group Leader for Management; and Business Development Director. Before this, he was Lecturer/Senior Lecturer and Director of Postgraduate Research at Management Science Department, Strathclyde Business School. His research focuses on using ICTs to facilitate strategic innovation and organisational transformation in different sectors.

# A Holistic Review and Framework for Business Models for Assisted Living Technologies and Services

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## Abstract

Despite heavy investment in health and social care sectors in the UK, large scale deployment of assisted living technologies and services (ALTS) continues to face significant obstacles and the lack of sustainable business models (BM) is widely regarded as one of the greatest hindrances. Based on a systematic review of previous studies, this paper identifies current trends in digital technologies and how they are used in assisted living. We categorise and analyse these technologies and through the lens of diffusion of innovation theory (DOI), we review the concepts and frameworks of BM as used in the literature, to suggest conceptual frameworks for sustainable BMs for scalable ALTS in digital economy. This is expected to help in reducing the pressure on the already stretched health and social care services in the UK and other similar economies. Our approach suggests that BM canvas and DOI innovation diffusion characteristics are complements, not substitutes.

## Keywords

Assisted living, assistive technology, business model, telecare, telehealth, telemedicine.

## 1 Introduction

The ageing populations, together with increasing chronic diseases are placing unsustainable pressure on health and social care systems in many countries throughout the world (Stroetmann, Stroetmann et al. 2003). Although the steady increase in life expectancy is a significant achievement, it also poses a significant challenges for future generations in paying for health and care services (Weimar, Simpson et al. 2009). In the UK, the ageing population will create strong latent demand for ALTS over the next 20 years. By 2030 life expectancy, based on the current trends, will increase by 4.2 years but healthy life will increase by only 2.6 years. Therefore, demand for social care will increase by 44% and demand for health care is also likely to increase substantially (Lewin, Adshead et al. 2010). As a result of changing demographics, residing and being cared for in one's own familiar environment versus in an institutionalised inpatient setting or care home is becoming the preferred alternative for an ever increasing portion of the population (Wichert 2010).

Innovative services based on information and communication technology (ICT) are often regarded as promising avenues to allow health and social care systems to cope with these challenges and to improve the quality of life of chronically ill and frail older citizens, however the sustained success of such services require careful consideration of the diverse interests of the key players in the health and social care arena and a long-term business case to integrate such services into routine health and social care delivery processes. While successful ALTS applications certainly exist, they are generally run by local champions and are mostly state funded. Presently, almost no ALTS applications have been successful in reaching enterprise-wide and large scale adoption (Huis in't Veld, Fielt et al. 2011). Thus there is the need for a review of the trends of various commercialisation attempts of ALTS in order to identify workable strategies for new and sustainable business models that could take these innovations into the mainstream market. In this paper, we will systematically review previous studies in this area and suggest a conceptual framework for sustainable and scalable business models in the digital economy.

Our intended contributions in this research are in threefold: to provide a comprehensive up-to-date literature review on ALTS and their commercialisation attempts, to carefully document the discrepancies and dissonances in those literatures, and (with the aid of relevant theories and models) to suggest a conceptual framework for sustainable business models for ALTS.

## 1.1 What is a Business Model

A business model describes the rationale of how an organization creates, delivers and captures value (Osterwalder and Pigneur 2009). It could be defined as “an architecture for product, service and information flows”, incorporating a description of the sources of revenue, the actors involved, their roles, and the benefits to them (Hayes and Finnegan 2005). Business model is not only a useful tool for explaining how firms work or why they succeed or fail, it can take on a much more important role within, in particular, entrepreneurship research, leading, for example, to a better understanding of the entrepreneurial phenomenon (Glasby, Le Grand et al. 2009). It also emphasizes a system-level, holistic approach to explaining how firms “do business” and it seeks to explain how value is created but not just how it is captured (Zott, Amit et al. 2011). The economic value of a technology remains latent until it is commercialized in some way via a business model. It defines how a business works and the logic that creates its value. It is the representations of a class of organisations in the way they operate and ideal types that organisations should aspire to become. Incoming firms need to design their initial business models while established companies may need to redesign their existing business models to withstand threats to their continued ability to create values. While the ultimate goal from an extreme shareholder perspective could be said to increase the stock price by creating profit, business models sometimes address broader criteria such as *sustainable development*, which implies that focus is shifted from mere profit orientation towards sustainable enterprises and an economic reality that connects industry, society, and the environment (Bukh and Nielsen 2010). The building blocks of business models are: (i) Value proposition (ii) Product innovation (iii) Infrastructure management (iv) Customer relations management (v) Financial viability and sustainability (vi) Stakeholder credibility (vii) Revenue Streams. For more information on each of these components, interested readers are advised to see (Osterwalder and Pigneur 2009, Lin, Liu et al. 2010).

In the next sections, we highlight the research objectives, research questions, summarize the background for this research and explain the methodology. We provide a systematic review of previous research studies on ALTS. Classification of these technologies and services were based on certain criteria. We review and refine the concepts from business model definitions and diffusion of innovation theory to formulate frameworks for scalable and sustainable business models for ALTS with particular emphasis on digital economy. The paper ends with suggestions for future research in the area of workable and sustainable business models for assisted living markets.

## 2 Theoretical Framework

A useful perspective to explain the issues at stake is that of the “Diffusion of Innovation” theory proposed by Everett Rogers in (Rogers 1995). As we are in the new digital economy and everything that can be digitized are being digitized, ubiquitous computing and pervasive connectivity at affordable prices allow new ways of doing business. However, best technologies, products or services are not sufficient for market success of any innovations. Therefore, new strategies and new business models need to be available for successful and sustainable deployment of new products and services. From the *Diffusion of Innovation’s* perspective, diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system (Thurber and Fahey 2009). If sustainable business models can be deployed for the ALTS market, such models would help to diffuse these innovations into the mainstream market, reach sufficient user segments to generate sustainable revenue for the ALTS providers. The theory could be used to analyse the current trends of user uptake of assisted living products and services and how the level of adoption could be further enhanced to ensure market sustainability as further elaborated in Section 6.2 (Discussion Section) of this paper.

## **3 Research Aim and Objectives**

### **3.1 Objectives**

The principal aim of this research is to investigate what factors should guide business models, which will be sustainable, for commercialisation of ALTS.

The main objectives of the research that arise from the above aim are:

1. To identify current trends in digital technologies and how these technologies are used in ALTS.
2. To review the existing literature in the area of ALTS and their various commercialisation attempts.
3. To investigate factors and reasons why this market has proved difficult to develop.
4. To review and suggest suitable conceptual frameworks for sustainable business models for ALTS which could help to reduce pressure on already stretched State funded health and social services in the UK and other economies with similar health and social care systems.

The research outcomes should therefore draw trajectory conclusions on notion of development of sustainable business model for ALTS in the digital economy.

### **3.2 Research Questions**

This paper will concentrate on the following main research questions:

1. What are the technologies used in ALTS and their segments?
2. What are the past various commercialisation attempts of ALTS?
3. What are the main factors and reasons influencing these commercialisation attempts and which has made the market proved difficult to develop?
4. How can these factors and reasons be overcome and how can business models be developed to ensure commercial or market sustainability for ALTS?

### **3.3 Hypotheses**

The research aims to test the following hypotheses

- There are currently no sufficient research on business models for ALTS
- Previous research did not provide effective and workable guidance or frameworks for sustainable and workable BMs for ALTS

## **4 About this research**

Following the research methodology in (Crossan and Apaydin 2010, Li, Pieńkowski et al. 2011), we conducted an extensive literature review on ALTS and business models, with a special focus on digitally enabled technologies. Based on peer recommendations and previous knowledge, we started by selecting and identifying key references from recognised authorities that are known for their research in this area, we then searched through references and a preliminary search of recent publications in Health Sciences, business management, e-business and e-commerce, computing and information systems, and social and behavioural studies. We followed this with a more systematic search on the IS Web of Science, which pools four indices: Arts and Humanities Citation Index (A&HCI), Social Sciences Citation

Index (SSCI) and Science Citation Index (SCI) since 1970, plus Conference Proceedings Citation Index-Science (CPCI-S) since 1990. In addition to these, we also searched the **PubMed** database which comprises over 21 million citations for biomedical literature from **MEDLINE**, life science journals, and online books from the fields of medicine, nursing, dentistry, veterinary medicine, the health care system, and preclinical sciences.

#### **4.1 Methodology and the Search Process**

Our initial search of the Web of Science database was undertaken (on 1st of September 2015) using the topic search term “assisted living” and its associated terms with the aid of Boolean expressions (that is: TS= (assisted living OR assistive living OR assistive technology OR adaptive technology)). In Web of Science, the “topic TS term” searches the title, abstract, author keywords and keywords plus within a record (Reuters 2011). We employed a number of inclusion and exclusion criteria which are summarized as follows:

##### 4.1.1 Inclusion Criteria

- Articles must be on ALTS
- Articles are those that address business aspects of ALTS.
- The technologies and services must be relevant to the health and/or social care.
- Journal in which the article appeared must be ranked in the Web of Science

##### 4.1.2 Exclusion Criteria

- Articles that are not in English Language
- Articles that are based on ALTS but which are not based on digital technologies.
- Conference papers.

While reading through these identified articles, we also followed up on some books, technical reports and working papers that are relevant to this research but which our database did not cover. We included these materials. The search generated a total of 12,381 items from 1980 onwards. This initial set was then used as the basis for the subsequent analysis. The data in Table 1 shows results of different search options.

#### **4.2 Systematic Review of Assisted Living Market and its Segments**

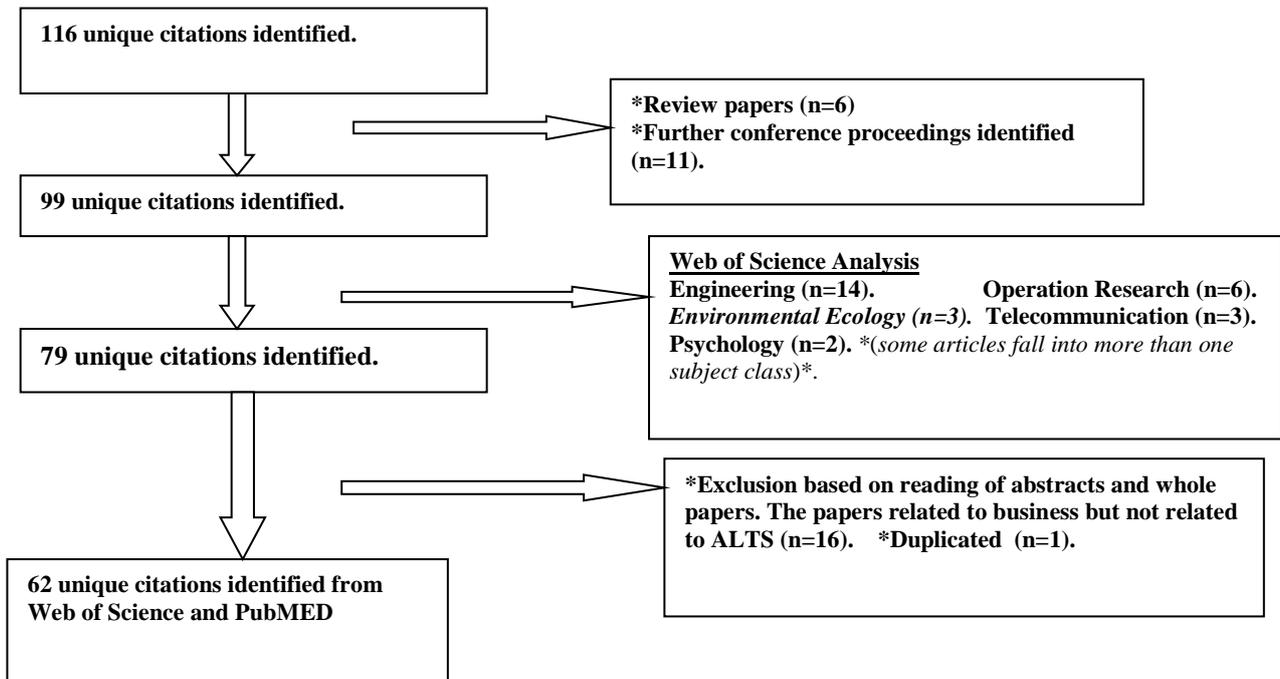
In addition to the search terms of “*assisted living*” and its variant names that were used in Section 4.1 (shown in columns 2 to 5 of Table 1), market segments of ALTS (identified in Table 3) were added to the search terms as shown in columns 6 to 11 of Table 1. By using these topic search terms (that is: TS= (telehealth OR telecare OR telemonitoring OR telemedicine OR teleworking OR assisted living OR assistive living OR assistive technology OR adaptive technology) which we represented on the table as “***AL \* OR Segments***”, the search returned more items than those in Section 4.1 (shown in columns 2 to 5 of Table 1). The search results are as shown in Table 1 under different headings.

Finally in column 11 of Table 1, we searched the database with ALTS, its variant names and segments in conjunction with another topic search “***business model***” (that is TS= (telehealth OR telecare OR telemonitoring OR telemedicine OR teleworking OR assisted living OR assistive living OR assistive technology OR adaptive technology) AND TS=*business model*) and these returned a total of 110 items from 1980 up to 2015 as shown in Table 1. In our analysis, we reviewed the abstracts in order to determine whether the papers met the inclusion or exclusion criteria. Papers were judged by the relevance of title and the contents of the abstracts to the research questions.

**Table 1: Number of publications on “ALTS” and “business model” (1980-2015)**

Period	AL*	Percentage	AL* AND Business	Percentage	AL* OR Segments	Percentage	AL* OR Segments AND Business	Percentage	AL* OR Segments AND Business Model	Percentage
<b>1980-2015</b>	12381	100	180	100	18815	100	292	100	110	100
<b>2015*</b>	882	7.12	8	4.44	1288	6.85	16	5.48	10	9.09
<b>2014</b>	1420	11.47	21	11.67	2029	10.78	34	11.64	15	13.64
<b>2013</b>	1266	10.23	20	11.11	1833	9.74	27	9.25	12	10.91
<b>2012</b>	1199	9.68	17	9.44	1761	9.36	24	8.22	12	10.91
<b>2011</b>	1004	8.11	12	6.67	1501	8.0	17	5.82	8	7.27
<b>2010</b>	918	7.41	12	6.67	1439	7.65	22	7.53	7	6.36
<b>2009</b>	811	6.55	10	5.56	1258	6.69	21	7.19	7	6.36
<b>2000</b>	788	6.36	16	8.89	832	4.42	12	4.11	5	4.55
<b>1999</b>	660	5.33	10	5.56	667	3.55	12	4.11	2	1.82
<b>1998</b>	553	4.47	10	5.56	596	3.17	8	2.74	2	1.82
<b>1997</b>	465	3.76	8	4.44	423	2.25	12	4.11	1	0.91
<b>1996</b>	430	3.47	6	3.33	310	1.65	8	2.74	2	1.82
<b>1995</b>	339	2.74	6	3.33	301	1.60	5	1.71	2	1.82
<b>1990</b>	330	2.67	6	3.33	12	0.06	0	0	0	0
<b>1985</b>	270	2.18	6	3.33	6	0.03	0	0	0	0
<b>1980</b>	229	1.85	6	3.33	1	0.01	0	0	0	0

Search results with ALTS variant names, segments and business model as keywords.



**Figure 1 Flowchart of the systematic review and the exclusion steps.**

## 5 Review Results

The researchers justify the need for business models that are sustainable in this section, noting that there has been limited research in the areas of workable models for commercialisation of ALTS and most especially, in the UK. Apart from the limited research undertaken on business model implementation processes, most of the research studies and models developed have been on technological models and strategic frameworks.

As shown in column 10 of Table 1, the search generated 110 relevant articles from Web of Science and another 6 unique articles from PubMed (that were not already identified in Web of Science) totalling 116 articles. The flowchart in Figure 1 shows the basic exclusion steps that were followed during the review processes. As shown on the figure, these exclusions left us with 62 unique articles from both Web of Science and PubMed. These 62 papers were systematically reviewed.

### 5.1 *Current Trends in ALTS and its Segments: Definitions and Concepts*

Review of papers on the concepts of ALTS reveal that technologies in support of home care go under a number of labels. However, the most common view is that assisted living refers to devices and services that exploit computer-based systems to support delivery of care to homes and allow users to prolong independent living at home (Turner 2010, Catharina 2011, Roth and Eckert 2011, Valkila and Saari 2011). According to (Turner 2010), such systems should be appropriate (from different stakeholder viewpoints), customisable (for specific user needs), flexible (offering a range of solutions), and adaptive as care needs and conditions evolve (Turner 2010).

These previous studies show that different authors from different countries have carried out research on ALTS but under variant names or terms. These variant names include: (i) assisted living; (ii) assistive living; (iii) assistive technology; and (iv) adaptive technology. A brief explanation of these terms and references of articles that used them are as summarised in Table 2.

According to Roth and Eckert in (Roth and Eckert 2011), assisted living, as a relative newcomer to long-term care, provides an option that most older adults prefer over a nursing home. According to United Kingdom Foundation for Assistive Technology (FAST) in (Warnes and Hawley 2011), assistive technology (AT) is defined as any product or service designed to enable independence for disabled and older people. In United States, assistive or adaptive technology commonly refers to “products, devices or equipment, whether acquired commercially, modified or customized, that are used to maintain, increase or improve the functional capabilities of individuals with disabilities”, according to the definition proposed in the United States Assistive Technology Act 1998 (Warnes and Hawley 2011). While these definitions cover telecare and telehealth segments of ALTS, they seem not to include *telemedicine* which has been defined as the application of ICT-based systems to facilitate the exchange of information between healthcare professionals such as diagnosis or referral and it tends to focus on specific applications like teleradiology or teledermatology (Rogers, Kirk et al. 2011).

**Table 2:** Variant names for assisted living as used in different literature.

<b>Variant Terms</b>	<b>Meaning</b>	<b>References</b>
Assisted living	Assisted living offers a social model of long-term care in which “normal, ordinary life” coexists with supportive services in a homelike setting (Yamasaki and Sharf 2011). It emphasizes a home-like environment that fosters respect for an individual's sense of autonomy, privacy, and freedom of choice (Roth and Eckert 2011). A form of living for older people in need of 24-hour assistance and care (Catharina 2011).	(Catharina 2011, Roth and Eckert 2011, Valkila and Saari 2011, Yamasaki and Sharf 2011)
Assistive living	These are generally intended to allow older people to easily access medical and emergency services, and maintain social and relatives contacts (Segarra and Andre 2009).	(Pradhan and Prabhakaran 2009, Segarra and Andre 2009).
Assistive technology	Any product or service designed to enable independence for disabled and older people (Warnes and Hawley 2011).	(Valkila and Saari 2011, Warnes and Hawley 2011)
Adaptive technology	In United States, adaptive technology commonly refers to “products, devices or equipment, whether acquired commercially, modified or customized, that are used to maintain, increase or improve the functional capabilities of individuals with disabilities”, (Warnes and Hawley 2011).	(Warnes and Hawley 2011)

Variant names under which different authors had carried out research on ALTS. With the aid of Boolean logic, we used combination of these names to search for the papers for the review.

### 5.1.1 Segments of Assisted Living Markets

Generally, irrespective of the variant names given to the concept, our systematic review of previous studies shows that rather than treating the ALTS as a market entity on its own, researchers have treated it in fragments or segments. Four main segments of ALTS market were identified through our review of previous research, which include: (1) telehealth; (2) telecare; (3) telemedicine; and (4) Digital participation services.

Critical review of these previous studies shows that the first three terms have been poorly defined, misrepresented and confusingly used in different papers with authors misinterpreting one term for another (Tulu, Hilton et al. 2005). Some claim to have addressed telecare while they actually worked on telehealth e.g. (Mair, Hiscock et al. 2008, Lin, Liu et al. 2010, May, Finch et al. 2011, Rogers, Kirk et al. 2011) and many others claimed to have researched in telemedicine which in actual facts, their research were attempting to address telehealth but not telemedicine e.g. (Olumide Sunday 2004, Ekelanda, Bowesb et al. 2010, Zanaboni and Wootton 2012).

This lack of consensus raises questions on the quality of research outcomes of these previous studies which include the data they collected and analysed, and also in terms of data evaluation approaches. This is because their underlying methodologies may not be capable of addressing the research questions to which different stakeholders seek answers. These reasons might not be unconnected with the present lack of workable business models because the business models of telehealth and telecare, which require installation at patients’ homes (**B2C**), are expected to be entirely different from that of telemedicine which are installed between healthcare professionals (**B2B**). In this paper, we rely on the definitions according to the UK Department of Health (DPH) and a brief summary of these segments and their definitions are as presented in Table 3.

#### a) Telehealth

Telehealth are technologies and services which enable monitoring of people's health in their own homes and telehealth monitoring is the remote exchange of physiological data between a patient at home and medical staff at hospital to assist in diagnosis and monitoring (Lewin, Adshead et al. 2010, Turner 2010, Warnes and Hawley 2011). It is the remote monitoring of a

patient's medical condition (Lewin, Adshead et al. 2010, Turner 2010, Davies and Newman 2011, Brodersen and Lindegaard 2015).

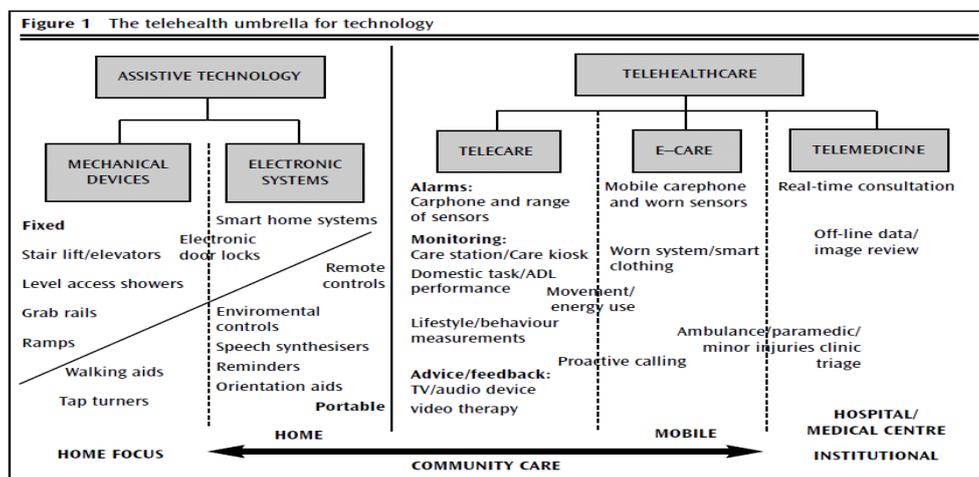
With modern technology, patients can be monitored in their own homes without having to visit their GP or local hospital (Bolt and Kano 2007, Warnes and Hawley 2011). The UK Department of Health defined telehealth as a service that uses equipment to monitor people's health in their own home by monitoring vital signs such as blood pressure, blood oxygen levels or weight (Davies and Newman 2011). Today telehealth services use a combination of sensors, hubs and remote servers to provide better and more cost efficient management of chronic conditions such as diabetes, COPD, heart failure and asthma (Lewin, Adshead et al. 2010).

Figure 2 shows what (Doughty, Monk et al. 2007) described as the 'telehealth umbrella model' which can be used to help map and define these products. This model shows the wide range of assistive technologies that are available and also categorises them to the settings they are suited; home or within an institution e.g. residential care home.

**Table 3:** Segments of assisted living markets.

Segments	Meaning	Examples	References
Telehealth	These are services that use equipment to monitor people's health in their own home by monitoring vital signs such as blood pressure, blood oxygen levels or weight (Davies and Newman 2011). The use of communications technologies to monitor and transmit items related to patient health status between geographically separated individuals (Maric, Kaan et al. 2009)	Blood pressure monitoring, blood glucose monitoring, cardiac arrhythmia monitoring, asthma monitoring and medication reminder systems (Sanchez, Dang et al. 2009, Warnes and Hawley 2011).	(Maric, Kaan et al. 2009, Sanchez, Dang et al. 2009, Lewin, Adshead et al. 2010, Turner 2010, Davies and Newman 2011, Warnes and Hawley 2011)
Telecare	These are services that use a combination of alarms, sensors and other equipment to help people live independently and this is done by monitoring activity changes over time and will raise a call for help in emergency situations, such as a fall, fire or a flood (Davies and Newman 2011)	Movement/non-movement sensors, falls sensors, fire/smoke alarms, automatic lighting sensors, food/water alarms, fridge activity sensors, window/door sensors, carbon monoxide sensors, bed/chair occupancy sensors, temperature range sensors, gas shut off devices, medication reminder systems, and wrist-worn wellbeing monitors (Warnes and Hawley 2011).	(Pare 2007, Lewin, Adshead et al. 2010, Turner 2010, Boonstra, Broekhuis et al. 2011, Davies and Newman 2011, May, Finch et al. 2011, Rogers, Kirk et al. 2011, Warnes and Hawley 2011)
Telemedicine	This is application of ICT-based systems to facilitate the exchange of information between healthcare professionals such as diagnosis or referral and it tends to focus on specific applications like teledermatology or teleradiology (Rogers, Kirk et al. 2011)	Digital diagnosis of X-rays for diagnosis by an off-site radiologist (Pare 2007, Maric, Kaan et al. 2009), tele-transmission system between hospitals which allows the doctors to discuss, in real time, the patient's case (Pelletier-Fleury, Fargeon et al. 1997, Yagi, Yamane et al. 2011).	(Pelletier-Fleury, Fargeon et al. 1997, Olumide Sunday 2004, Pare 2007, Maric, Kaan et al. 2009, Rogers, Kirk et al. 2011, Yagi, Yamane et al. 2011)
Digital participation services	Services that are delivered to entertain, educate and stimulate social interaction so as to enrich the lives of older and disabled people who live at home (Lewin, Adshead et al. 2010). It is the delivery of services into the home from a remote location which engages older and disabled people in terms of social, educational or entertainment activities.	These include services which connect, engage, stimulate and entertain older and disabled people in their homes. They offer older and disabled people access to a wide range of Internet services which allow them to save money and to participate more fully in society e.g. broadband communications, digital inclusion measures, web-based social networking, etc.	(Illegems, Verbeke et al. 2001, Lewin, Adshead et al. 2010)

This table shows different segments of ALTS identified from the literature. With the aid of Boolean logic, we used combination of these names to search for the papers for the review in addition to the variant names identified in **Table 2**.



**Figure 2 Telehealth umbrella for technology taken from (Doughty, Monk et al. 2007).**

### b) Telecare

Telecare is concerned with keeping people safe and independent in their own homes using remotely accessed technologies such as telephone, mobile or wireless connections (Pare 2007, Lewin, Adshead et al. 2010, Turner 2010, Davies and Newman 2011, May, Finch et al. 2011). The UK Department of Health defined telecare as a service that uses a combination of alarms, sensors and other equipment to help people live independently and this is done by monitoring activity changes over time and will raise a call for help in emergency situations, such as a fall, fire or a flood (Davies and Newman 2011).

Traditionally, telecare product offerings were dominated by alarm based devices such as pendants and call alarm buttons. Whilst providing a valuable contribution they were limited by the necessity for users to activate the device, also known as a 'reactive mode' (Network 2007). However with sensor technologies a host of monitoring devices have been developed that require no input from the end user and are therefore less intrusive (Crump 2010).

Telehealth within the UK is comparably less widespread than telecare. However the possibilities of using it to monitor those with long term health conditions are great. Currently most telehealth devices require user to actively interact with a device to transmit data. However technologies exist that have wireless mobile monitors that could be worn by a user to allow seamless transmission of vital signs (Goodwin and Clark 2010).

### c) Telemedicine

Telemedicine are ICT enabled services that aid remote consultations between primary and secondary health care service providers and are attributed to services such as teleradiology, telepsychiatry, transmission of echocardiographic images (Ekelanda, Bowesb et al. 2010). As an example of telemedicine application and to clearly distinguish it from other ALTS applications, Pelletier-Fleury et al in (Pelletier-Fleury, Fargeon et al. 1997) give an example in a Paris' public hospital which set up a tele-transmission system between 15 hospitals. The system relays neuro-scannographic and images that allow doctors who do not have full competencies in a general or university hospital linked to the system, to consult other more specialised physicians at a distance, in order to obtain diagnostic and therapeutic advice necessary for emergency brain surgery required by patients suffering from cranial traumatism. These terminals and inter-connecting networks allow doctors to discuss, in real time, the patient's case based on transmitted images and to adopt jointly, the best treatment strategy, and whether the patient should be transferred to the specialist unit or treated locally. Another example according to Yagi et al in (Yagi, Yamane et al. 2011) is a mobile telemedicine system (MTS) which transmits 12-lead ECG and other parameters between moving ambulances and physicians in cardiac emergency.

### d) Digital participation services

Another segment of assisted living as pointed out in (Lewin, Adshead et al. 2010) is digital participation service which includes services that are delivered to entertain, educate and stimulate social interaction so as to enrich the lives of older and disabled people who live at

home (Lewin, Adshead et al. 2010). They are digital inclusion measures to encourage older and disabled people to go online.

## 5.2 Discussion on Articles Related to Business Models of ALTS

After reading through the 62 articles from the Web of Science and PubMed, they are categorized as:

1. Articles that discussed implementation strategies of ALTS segments.
2. Articles on technological models or frameworks of ALTS segments.
3. Articles that attempted the business models of certain segments of ALTS.

These three categories are as analysed in Table 4 (containing categories 1 and 2) and Table 5. From our analysis, none of these articles took a holistic look into the general ALTS markets nor looked into ALTS as an emerging market as a whole but rather, each paper merely addressed certain segment from the market. Full details of the articles are available at the bibliography section of this paper.

Furthermore, as shown on the tables, almost all of these papers were written and addressed the ALTS segments outside United Kingdom (mostly USA) with their empirical research carried out on the health systems of those countries they represented.

**Table 4: Articles on strategic, frameworks or technological models of certain segments of ALTS.**

S/N	Segment Touched	References	Countries in order of column 3 data
1	Telemedicine	<b>Strategies:</b> (Weaver and Spence 2000, Pare and Trudel 2007, Yun and Park 2007)	Canada, Canada, Korea.
		(Harris 1999, Chau and Hu 2001, Leff and Burton 2001, Chau and Hu 2002, Chau and Hu 2002, Madera A and A. 2004, Cavallerano and Aiello 2005, Belard, Tinnel et al. 2009, Cegarra-Navarro and Teresa Sanchez-Polo 2010, Gundim and Chao 2011).	USA, Hong Kong, USA, Hong Kong, Hong Kong, Italy, USA, USA, Spain, Brazil.
2	Telehealth	(Weinstein, Graham et al. 2009, Ackerman, Filart et al. 2010).	USA, USA
3	Telecare	<b>Strategies:</b> (Boonstra, Broekhuis et al. 2011).	Netherlands
		(Harris 1999)	USA
4	Telepathology	(Weinstein, Graham et al. 2009).	USA
5	Teleworking	(Illegems, Verbeke et al. 2001).	Belgium
6	E-Health	(Seror 2002).	USA and UK

Table shows articles which attempted to describe the strategic models, frameworks or technological models of certain segments of ALTS and the countries they addressed.

**Table 5: Articles on business aspects of only certain segments of ALTS.**

S/N	Segment Touched	References	Countries in order of column 3 data
1	Telemedicine	(Navein, Arose et al. 1999, Holtel and Burgess 2002, Zeevi 2003, Gamble, Savage et al. 2004, Barker, Krupinski et al. 2005, Mun, Tohme et al. 2005, Pak 2005, Rumberger and Danksy 2006, Shea 2006, Maffei, Hudson et al. 2008, Pak, Brown-Connolly et al. 2008, LeRouge, Tulu et al. 2010,	USA, USA, Israel, USA, USA
2	Telecare	(Lin, Liu et al. 2010, May, Finch et al. 2011).	Taiwan, UK
3	Telehealth	(Cho, Mathiassen et al. 2009, Visser, Bloo et al. 2010).	USA, Netherlands

Table shows articles which attempted to describe the business models of certain segments of ALTS and the countries they addressed.

### **5.3 Summary of Literature on implementation Strategies for ALTS**

Some research streams on ALTS to date have devoted great attention to strategies for certain segments of ALTS rather than the business models as shown in Table 4. In (Boonstra, Broekhuis et al. 2011), the authors, in Netherlands, merely corroborated the fact that in telecare adoption, the lack of a strategic vision and of consistency in design choices have been identified as critical problems. They integrate work on strategic value configurations with the strategic information systems (IS) alignment model in order to widen the latter's applicability in telecare adoption. (Yun and Park 2007, Seblega, Zhang et al. 2015) evaluated the feasibility of telenursing to analyse the issues that should be considered for the development of telenursing in the future, and to provide efficient strategies for the implementation of telenursing in Korea. (Pare and Trudel 2007) from Canada, used their study to seek a better understanding of challenges faced in PACS (picture archiving and communication system) implementations in hospitals and of the strategies required to ensure their success while in (Weaver and Spence 2000), a strategy for implementing telemedicine throughout Alberta was developed. While all these articles attempt to discuss the strategy models for ALTS, the funding aspects of the business models were left unaddressed.

The above discussions show that there has not been much research (or published studies outside the working papers) on business models aspects of ALTS in the United Kingdom in the past and despite that the country has traditional health and social care systems' funding models that are entirely different from those of other countries such as USA. Therefore extrapolation of findings from American or Western European evaluations to the UK health or social care systems may be inadvisable, given the differences (Boonstra, Broekhuis et al. 2011) in how the health and social care systems are structured, funded and managed.

Also, rather than looking for the business models for each of the ALTS segments as previous research studies have done, it is more desirable to find business models that are workable for the collection of the segments or for the entire ALTS segments as a whole market.

### **5.4 Summary of Literature on Frameworks or Technological models of ALTS**

Some papers also attempted to describe the frameworks or technological models (rather than the business models) for certain segments of ALTS and these were identified as shown in Table 4. As shown in the table, nine of these papers described frameworks or technological models for telemedicine. In (Cegarra-Navarro and Teresa Sanchez-Polo 2010), the authors described the frameworks of e-listening as the core element for hospital-in-the-home unit and performance and illustrate this suggestion with an empirical study. However, the study merely emphasizes on value proposition and frameworks of telemedicine while the funding aspects of the business models were left unaddressed. Two papers described the frameworks of telehealth segment (Weinstein, Graham et al. 2009, Ackerman, Filart et al. 2010) with (Weinstein, Graham et al. 2009) also describing telepathology and all from USA. Harris G in (Harris 1999), from USA, described the framework for telecare. A paper from Belgium (Illegems, Verbeke et al. 2001) described teleworking and the last paper in this category attempted to identify the effects of ideological differences on health care market infrastructures including the Internet and telecommunications technologies by a comparative case analysis of two large health care organizations: the British National Health Service and the California-based Kaiser Permanente health maintenance organization (Seror 2002, Rodrigues 2003).

### **5.5 Literature on Business Models for ALTS and Past Commercialisation Attempts**

#### **5.5.1 Direct Payments**

Glasby (2007) provides an overview of the introduction of direct payments as an example of an approach to enable the Independent Living Movement. In United Kingdom, direct

payments were established in 1996 from the Community Care (Direct Payments) Act. This act meant that older people could receive cash from Local Authorities to procure their own products or services to aid their independent living. However, despite the potential of direct payments to enable greater choice and control for older people, the paper reported that take up is relatively low. Glasby (2007) draws on figures from the 2005 Social Care Green Paper (DPH 2005) which shows that in 2003, although 12,585 people were using direct payments, this is relatively low in comparison with the 1.68 million community care service users. Take up has been seen to vary significantly between local authorities and much of these have been associated to the guidance and advice provision available to applicants in different areas.

Following on from the introduction of direct payments, since 2006 there have been policy moves to broaden the scope of individual budgets. This is discussed further in relation to Personal Health Budgets (DPH 2009c). Taken from (Glasby 2007), Table 6 below provides international examples of ‘consumer-directed care’.

In (Clark and Goodwin 2010), the authors report that the Whole Systems Demonstrator Action Network (DPH 2009) has estimated that there are currently around 1.7 million people in England using some kind of telecare (as of May 2010).

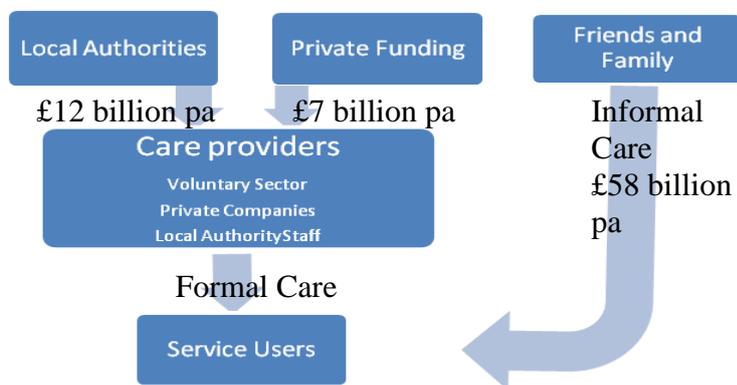
**Table 6:** International examples of 'consumer-directed care'

In the Netherlands, personal budgets can be used to purchase agency care, hire a PA and pay some money towards equipment and informal care.
In Norway, a care wage pays relatives or others caring when it is considered better than agency care.
In Sweden, the carer’s salary enables a person giving care to have a similar salary and rights to someone employed by a public agency.
In the US, consumer-directed home care enables consumers to hire and supervise a PA (paid by the Medicaid system), while various cash and counselling pilots are closer to the direct payments model.

Table showing international examples of 'consumer-directed care'. Source: (Lundsgaard 2005).

Whilst the majority of this telecare can be attributed to pendant alarms there are also a significant number of sensor-based systems (which use personal and environmental monitors). (Lewin, Adshead et al. 2010) also reports that uptake of telehealth technologies at this stage in the United Kingdom are limited and however, depending on outcomes from the Whole System Demonstrator further investments are likely.

Review also showed that the difficulty with estimating the value of the assistive living services market is compounded potentially by levels of informal care which is not easily measurable and also many assistive technologies rely on a service but it is hard to differentiate the separate value. The chart shown in Figure 3 is a value chain for the delivery of social care in 2007 as illustrated in (Lewin, Adshead et al. 2010) this illustration includes an estimated figure for the value of informal care that is provided.



**Figure 3: The Value chain for the delivery of Social Care**

Figure 4 illustrates the main routes that are currently available (in United Kingdom) to obtain ALTS. Arguably this is a simplistic model that does not account for other internal mechanisms.

### 5.5.2 Market Characteristics: Small and medium enterprises (SMEs)

Review shows that traditionally, the private market for ALTS within the UK is made up of small highly specialised companies. These SMEs can undertake multiple roles within the supply chain, both designing and manufacturing these products. Due to the small scale and specialised operations, there is little interoperability between products from different suppliers. (Lewin, Adshead et al. 2010) proposes that with regards to digital products, the introduction of software that could be operated on mass-market platforms (such as iPhones and other mobile devices) has the potential to significantly reduce development and product costs and thus, increase uptake of these technologies.

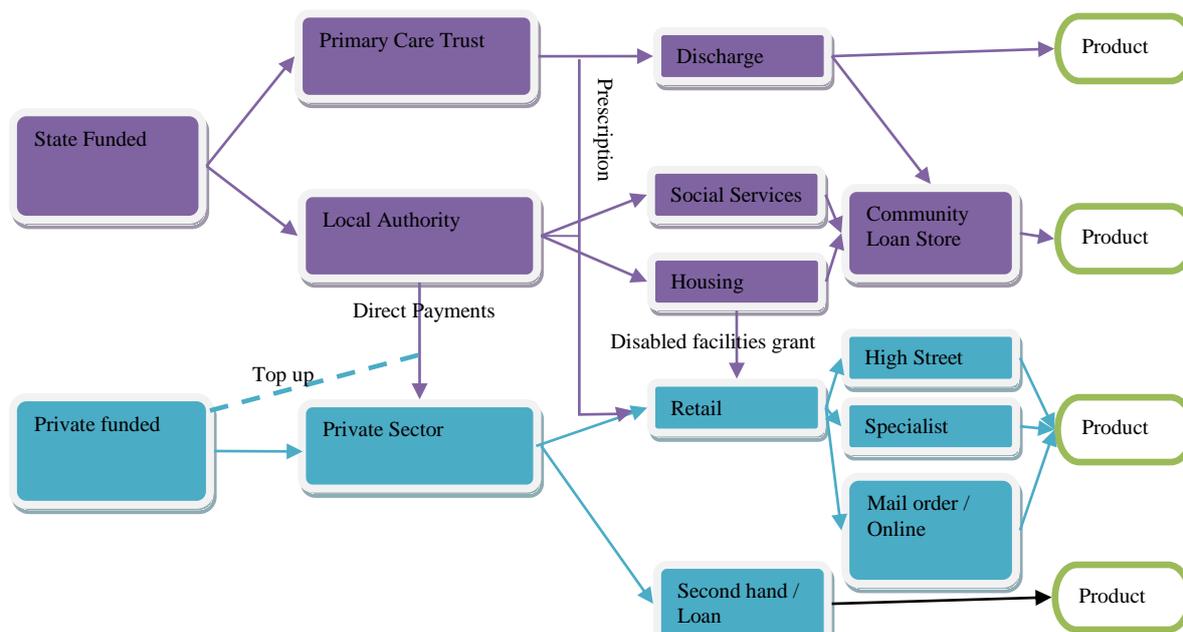
### 5.5.3 Self-funders of ALTS

While there have been increasing literatures that are related to older consumers in a broad context, there has been little research that looked at older individuals as purchasers of health and social care products and services. (Ahmad 2002) provides an overview of existing literature related to ageing consumers and their main findings are as shown in

Table 7.

### 5.5.4 Unsatisfied Demand

The UK Department of Health TCES strategic briefing (DPH 2009c) shows that there is an increasing level of un-met demand for community equipment (as shown in Figure 5). This graph projects that with a reduction in the amount of state funded support and increasing demand, there will be an estimated 134% level of un-met demand for ALTS. This graph is used to show why it is necessary for an innovative and robust private industry for self-funded users.



**Figure 4: Main routes that are currently available to obtain ALTS in the UK.**

**Table 7: Existing literatures on ageing consumers and their main finding.**

Author(s)	Main findings.
(Long 1998)	Explores and acknowledges the existence of the grey market as a discrete sector.
(Szmigin and Carrigan 2000)	Argue that the UK advertising industry is discriminating against older people and that companies do not give attention to older consumers as they do to younger ones.
(Bone 1991)	Reviewed 33 segmentation methods for the mature market.
(Schewe, Meredith et al.	Suggested segmenting consumer markets in the USA into cohorts from the year that they were born.
(Evandrou and Falkingham 2000)	Suggested segmenting consumer markets in the UK from the year they were born.
(Leventhal 1997)	Argues that basic character traits do not change with age.
(Szmigin and Carrigan 2000)	Argues that the cognitive age for consumers is about 10-12 years younger than their chronological age.
(Silvers 1997)	Finds that life from 50's is less that settle and there is more change in a person's life in their 50s as when in their 20s.
(Nielson and Curry 1997)	Identify four main advertising techniques that may be used when attracting older consumers.

Table showing existing literature as they related to ageing consumers and their main finding.

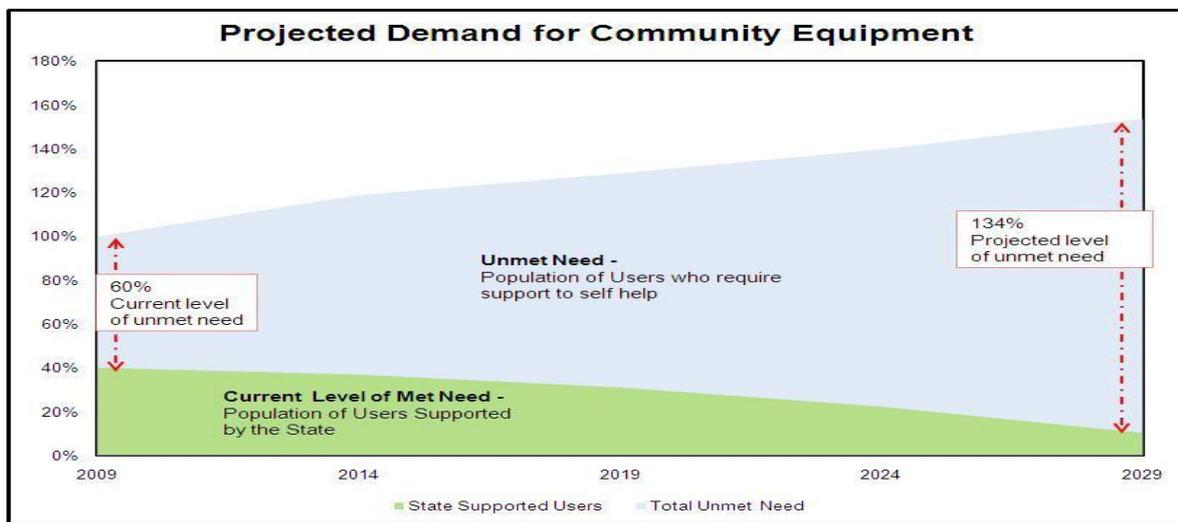


Figure 5: The UK Department of Health TCES strategic briefing (DPH 2009).

This graph shows that even, now there is a significant numbers of individuals whose needs are unmet by the state, therefore there is great emphasis for open up retail markets to grow along with expected demand.

**Why is there un-met demand? :** Reasons for un-met demands have been identified to include (i) Fear of indeterminate cost (Marshall and Dixon 1996) (ii) Denial of condition (Ellis and Scarfe 2009) (iii) Scepticism from healthcare professionals (Goodwin and Clark 2010) (iv) Language barrier (Ellis and Scarfe 2009) and (v) Lack of guidance and support (DPH 2007, Alliance 2010, Focus 2010).

### 5.5.5 Summary of Literature on Past Commercialisation Attempts of ALTS

Generally from these reviews, it will be observed that while there are advancing ALTS technologies there has been a lack of sustainable commercial innovation and enterprise within this market. The review shows that most of the existing business models for ALTS are state funded which have placed much pressure on government's health and social care budgets and therefore becoming unsustainable for the governments due to the increasing trends in the number older people. The direct payment initiative (Section 5.5.1) was plagued by low user uptake and private markets for ALTS in the UK are hindered by small market size. With the present budget cut principles of states all over the world, reduction in the amount of state funded support and increasing trends in demand of health and social care for older people due to aging population, there will be an astronomical increase on un-met demand (Section 5.5.4) for ALTS unless alternative and sustainable business models are put in place. Hence, there are needs to research more into business models that will take the burdens of ALTS funding completely from the state. Self-funded business models where users (or their relations) pay for their services are most likely to be the most sustainable models.

Also, review of previous studies shows that very few published papers (outside the working papers) actually attempted to describe the business aspects for certain segments of ALTS and these were identified as shown in Table 5. As shown in the table, thirteen of these papers (with twelve from United States) described the business models only for telemedicine segment of ALTS. In (Gamble, Savage et al. 2004), the authors focused on telemedicine's cost effectiveness from a provider's perspective using value chain analysis and concluded that value chain analysis examines structural and executional cost drivers; they suggested that a self-sustaining business model would balance the cost and value associated with each telemedicine activity. The author in (Pak 2005) explained that although teledermatology has been beneficial and cost-effective in some settings, many programmes have failed, not because of the technology but because teledermatology was implemented in isolation. He argued that a thorough understanding of an organization's business process and business model is crucial before teledermatology is begun. The author highlighted five important steps that need to be taken to address this which include: (1) understanding how the organization

delivers care; (2) analysing the alternatives, including cost-benefit analysis; (3) obtaining organizational support; (4) formulating an execution plan; (5) training staff and monitoring the process.

Zeevi (2003) from Israel described a business model for telemedicine and recommended that medical technology companies that are developing telemedicine products have to consider the market needs, the customer, the product development aspect, the business model, and the long process of market penetration, in order to choose the commercially correct idea and successfully bring it to the market. Two articles (Cho, Mathiassen et al. 2009, Visser, Bloo et al. 2010) from United States and Netherlands respectively described the business models aspects of telehealth segment. Visser et al in (Visser, Bloo et al. 2010) recommended an example of a business model which might not work for UK health system. The paper concluded that the financial reimbursement for the service delivery is expected to be most successful when set up through healthcare insurance companies. Presently, these companies are not known in the UK. Finally, a paper from Taiwan (Lin, Liu et al. 2010) described the business models for telecare and only one paper from United Kingdom (May, Finch et al. 2011) aimed to identify factors inhibiting the implementation and integration of telecare systems for chronic disease management in the community and it concluded that interventions are needed that (i) reduce uncertainty about the ownership of implementation processes and that lock together health and social care agencies; and (ii) ensure user centred rather than biomedical/service-centred models of care.

Summaries of these reviews and analysis are as shown in Table 4 and Table 5 while full details on the literature are available at the bibliography section of this paper.

### 5.6 Summary of Main Factors and Reasons ALTS Market has proved difficult to develop

Generally, detailed review of previous studies shows that failure of successful deployment and commercialization of ALTS are primarily connected with the lack of sustainable business models and authors have premised the reasons behind these failures under different headings which could be summarily classified into five primary reasons; (i) Poor coordination; (ii) Lack of user centred design; (iii) Security and privacy concern; (iv) Poor integration of policy and practice; and (v) Small market size and cost effectiveness. These reasons are as summarised for each ALTS market segment in Table 8.

**Table 8: Summary of Reasons ALTS Market has proved difficult to develop.**

Market Segments	Challenges	References
Telehealth	<u>Coordination</u> : Commercialisation of telehealth failed because inventors do not carry along the business expert in order to cross the diffusion chasm from invention to market penetration (Cho, Mathiassen et al. 2009).	(Cho, Mathiassen et al. 2009, Visser, Bloo et al. 2010)
	<u>Small Market size</u> : Implementation of the video teleconsult service requires multidisciplinary cooperation and integration, however one of the main challenges is the small market size (Visser, Bloo et al. 2010).	
Telecare	<u>Lack of user cantered design</u> : New systems are rarely negotiated with service users and there is a general lack of focus on the end users of telecare (May, Finch et al. 2011). The business model will probably only be successful when the majority of the user feel that the device is easy to use and has a high acceptance rate (Lin, Liu et al. 2010). Technology should support the needs of the user, not drive them (Navein, Arose et al. 1999)	(Boonstra, Broekhuis et al. 2011, May, Finch et al. 2011).
	<u>Poor integration of policy and practice</u> : These include uncertainty about ownership, responsibilities and direction of business (Boonstra, Broekhuis et al. 2011, May, Finch et al. 2011).	
Telemedicine	<u>Organisation and cultural inertial</u> : This is identified as one of the main problems of implementing telemedicine in developing nations (Olumide Sunday 2004, Yun and Park 2007).	(Navein, Arose et al. 1999, Weaver and Spence 2000,

	<u>Security and privacy concern</u> : Electronic exchange of data among physicians and hospitals makes privacy and security part of the concerns of telemedicine users (Olumide Sunday 2004, Cavallerano and Aiello 2005, Pak, Brown-Connolly et al. 2008).	Gamble, Savage et al. 2004, Olumide Sunday 2004, Cavallerano and Aiello 2005, Pak 2005, Shea 2006, Yun and Park 2007, Pak, Brown-Connolly et al. 2008, Lin, Liu et al. 2010, Hughes, Marshall et al. 2011).
<u>Inadequate planning, integration or coordination</u> : Telemedicine projects were driven by enthusiastic individual but failed because of inadequate planning and coordination (Navein, Arose et al. 1999, Weaver and Spence 2000, Pak 2005, Pak, Brown-Connolly et al. 2008).		
<u>Cost effectiveness</u> : While telemedicine's clinical effectiveness and educational benefits are accepted, its cost-effectiveness is controversial (Gamble, Savage et al. 2004, Cavallerano and Aiello 2005, Shea 2006, Hughes, Marshall et al. 2011).		

Table showing reasons for present failure of ALTS business models and references of the literature that mentioned them.

## 6 Research Discussion

### 6.1 Sustainable Business Models for ALTS in the Digital Economy

There is the apparent need to develop a conceptual framework necessary for sustainable business models for ALTS that are workable for UK health and social care systems and possibly extendable to other economies with similar systems. This is necessary as a result of the gaps in the review of literature highlighted in previous sections. The proposed conceptual framework for ALTS business models is shown in Figure 6 and it consists of two main parts:

1. Business model framework as defined in (Osterwalder and Pigneur 2009, Lin, Liu et al. 2010).
2. Diffusion of Innovation theory (Rogers 1995).

The term “*business model*” is more widely used nowadays than almost any other concept in strategy and one of its roles is to provide a set of generic level descriptors of how a firm organises itself to create and distribute value in a profitable manner. The business model frameworks (explained in Section 1.1) as developed in (Osterwalder and Pigneur 2009) has been successfully applied by various researchers (Lin, Liu et al. 2010, Kijl and Nieuwenhuis 2011, Zott, Amit et al. 2011) for analysing commercialisation of products and service and it has proven to be a reliable model which could be adopted in many situations. However, while the frameworks could be said to successfully capture factors that entrepreneurs would consider within their organisations when introducing products and services into the market, it seems not to have taken the characteristics of the markets and attitudes of various user groups toward innovation adoption into consideration. The framework does not specifically relate innovation qualities to the characteristics of the various user segments in the market. These factors are necessary in order to take (and diffuse) the ALTS innovations into the mainstream market, lead to sufficient adoption, generate sufficient revenue streams and in ensuring sustainability of the business model.

On the other hand, diffusion of innovation theory as developed by Everett Rogers in (Rogers 1995) highlights different strategies necessary for taking innovations into the market, for capturing different user segments and it effectively relates innovation qualities to the characteristics of various population segments of the market. It explored innovation characteristics and qualities that aid adoption. It has been successfully applied in investigating how innovations spread across populations and how entrepreneurs could strategize to reach each market segment. However, this theory does not consider the wider organisational structures and decisions variables that are necessary in determining whether an entrepreneur would produce or invest in an innovation or not. These variables include value proposition, organisation’s infrastructure management strategies, stakeholders’ credibility and most especially, the financial viability of the business as well as other related variables.

Therefore, these two models appear to complement each other and we have used an integration of the concepts presented by them to review the business model frameworks proposed in (Osterwalder and Pigneur 2009) to formulate our conceptual framework for sustainable ALTS business models as shown in Table 9, Figure 6 and Figure 7. The proposed model incorporates factors identified in previous studies as influencing commercialisation of ALTS projects (Table 9). We refined the conventional business model frameworks in (Osterwalder and Pigneur 2009) by integrating it with factors discussed in previous studies (as affecting ALTS commercialization) as well as concepts from diffusion of innovation theory, thus resulting in the development of an integrated model for business sustainability.

## **6.2 Guiding Business Model Factors and Frameworks for Sustainable Commercialization of ALTS**

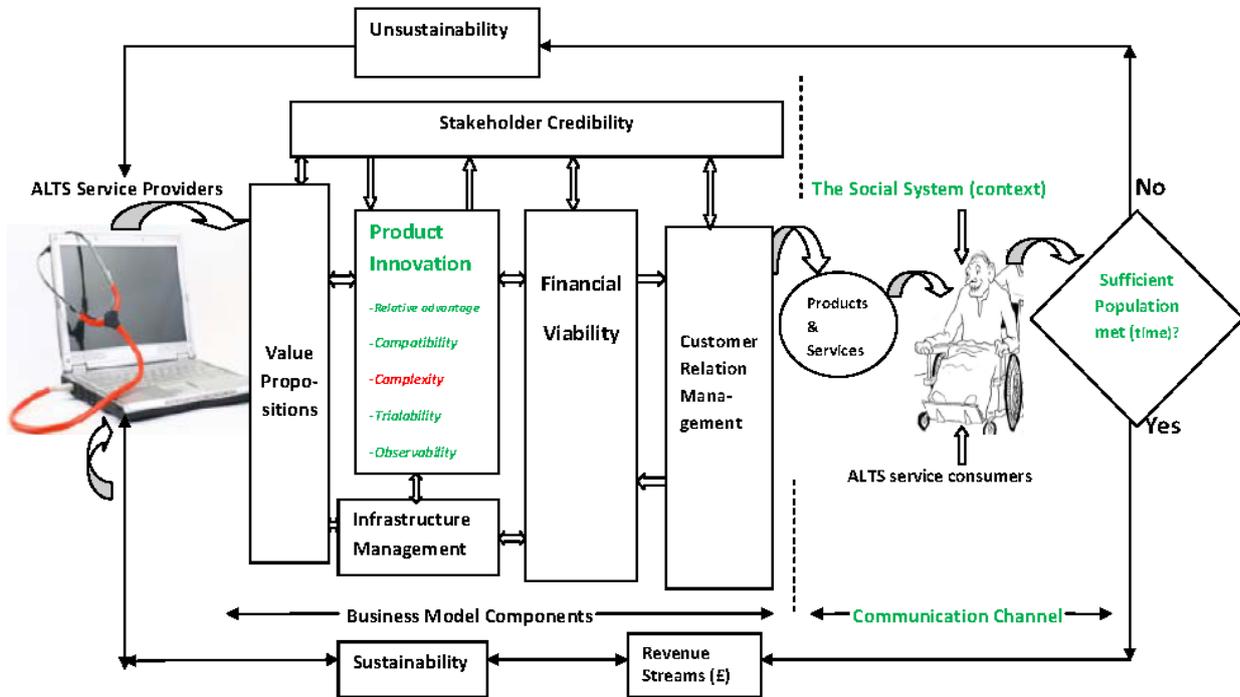
The academic literature arguing that there is an urgent requirement for businesses to become more sustainable is rapidly expanding and there is also a demonstrated need for managers to develop a better understanding of sustainability and the appropriate strategies required to improve business sustainability (Fisher and Bonn 2011). Most available theoretical frameworks for the dissemination and implementation of medical innovations heavily rely on Roger's 'diffusion of innovations theory' (DOI) (Ruof, Mittendorf et al. 2002). "Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system...it is a kind of social change" (Rogers 1995, Thurber and Fahey 2009). From the definition, the theory identifies four main elements in the diffusion of new ideas as (1) the innovation (2) communication channels (3) Time and (4) the social system (context). According to the theory, ALTS innovations may be adopted very slowly during the early stages of the diffusion process (e.g. present low user uptakes of ALTS innovation) and if the innovation are perceived as advantageous by its early adopters, however, the rate of adoption steadily increases and then accelerates to a maximum until half of the individuals in the system have adopted, resulting in an *S-shaped* rate of adoption (sustainability) of the innovation over time (Ruof, Mittendorf et al. 2002) as shown in Figure 7.

Diffusion of Innovations theory attempts to explain how innovations are taken up in a population (user uptakes) and diffusion scholars recognise five qualities that determine the success of an innovation (Rogers 1995, Thurber and Fahey 2009) which include: (a) relative advantage (b) compatibility (c) trialability (d) observability (e) complexity. The first four factors are positively correlated with rate of adoption while the last factor, complexity, is generally negatively correlated (Rogers 1995). *Relative advantage* is the extent to which an ALTS innovation is perceived as being better or more useful than the idea it supersedes (value proposition) while *Compatibility* is a measure of how well an ALTS innovation is consistent with existing social and cultural practices, if it is likeable, and if it meets the needs of potential adopters (Thurber and Fahey 2009). *Observability* is used to describe how well the results of the innovation can be seen and communicated to others, *Trialability* refers to the ability of an ALTS innovation to be experimented with, while *Complexity* is the level to which the innovation is perceived to be difficult to understand or use (Rogers 1995, Ruof, Mittendorf et al. 2002).

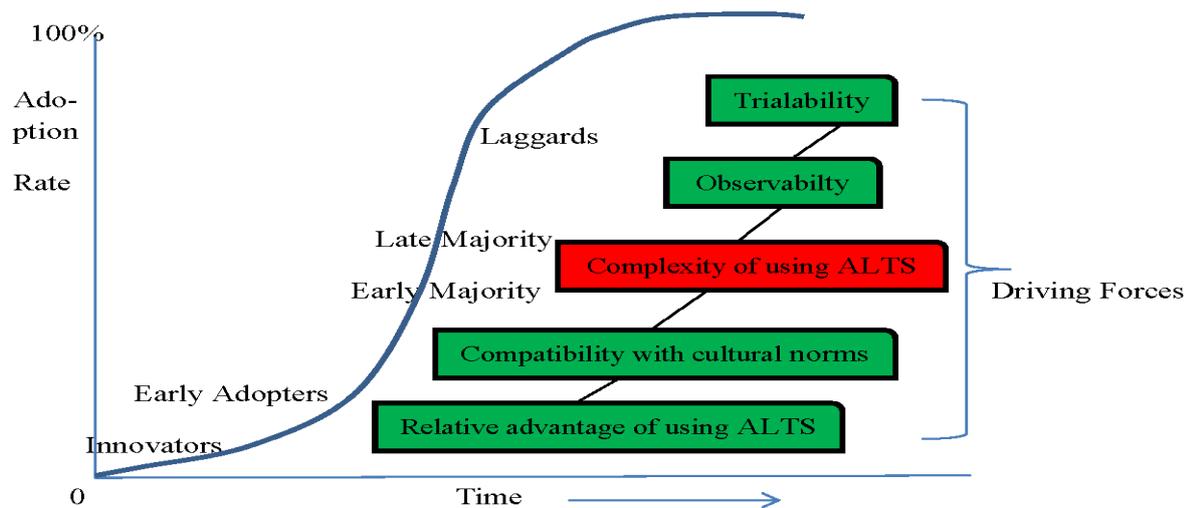
Furthermore, diffusion researchers believe that a population can be broken down into five different segments and percentages, based on their propensity to adopt a specific innovation (such as ALTS) and these are (i) innovators: 2.5% (ii) early adopters: 13.5% (iii) early majorities: 34% (iv) late majorities: 34% (v) laggards: 16% (Robinson 2009). According to Rogers in (Rogers 1995), the following are the characteristics of each population segment (this is equally applicable to the elderly and the disabled people as potential users of ALTS innovations): *innovators* are venturesome, educated with multiple information sources; *early adopters* are social leaders, popular, educated; *early majority* are deliberate, with many informal social contacts; *late majority* are sceptical, traditional, with lower socio-economic status; *laggards* (Goldenberg and Oreg 2007) heavily rely on neighbours and friends as main information sources and are constantly in fear of debt. The ALTS innovations will spread and

business becomes sustainable when they evolve to meet the needs of successive segments of the population.

The models in Figure 6 and Figure 7 show the pictorial relationships and conceptual frameworks of business models (discussed in Section 1.1) that could be sustainable for ALTS. Table 9 shows these building blocks as they relate to ALTS. The components with green colour labels show the five qualities that ALTS innovations need to satisfy in order to diffuse successfully into the mainstream market in accordance with the diffusion of innovation theory and how these qualities relate with, and complement the business model frameworks described in (Osterwalder and Pigneur 2009).



**Figure 6:** A framework showing the building blocks of sustainable business models in ALTS market from the perspective of diffusion of innovation theory. The figure shows that for an ALTS system to be sustainable, credibility of the stakeholders is very important from the onset of the business model components in order to ensure acceptability of the end products or services. The components with coloured labels show the five qualities that determine the success of an ALTS innovation in accordance with the diffusion of innovation theory and how these qualities relate and compliment the business model frameworks described (Osterwalder and Pigneur 2009, Zott, Amit et al. 2011) . The ALTS business becomes sustainable when the innovations diffuse and reach sufficient members of the market population to generate sufficient revenue streams for the self-sustenance of the business.



**Figure 7:** The S-curve shows potential ALTS innovation adopters in five hierarchies according to Roger's diffusion of innovation theory. Each group is categorised based on when they are likely to adopt the technology along the S-curve path. The items in boxes show the five driving forces that could determine the success of an ALTS innovation. The four items in green colour are positively correlated with rate of adoption while complexity (in the red box) is generally negatively correlated. Business sustainability will be achieved when the ALTS innovations spread and evolve to meet the needs of successive segments of the population in order to generate sufficient revenue streams for the sustenance of the business.

**Table 9:** Guiding business model factors and frameworks for sustainable commercialization of ALTS.

Business Model components	Specifications	Refer-ences
Value proposition	<p>ALTS innovations have altered profoundly the manner in which primary care physicians can interact with hospitals and specialists and as dedicated medical ICT systems evolve, medical care will be delivered to patients in remote locations in a more efficient and cost-effective way(Madera A and A. 2004).</p> <p><u>Acceptability:</u> The service will be accepted if it has added value for the quality of care (Visser, Bloo et al. 2010).</p> <p><u>User centred design:</u> Ensuring user centred rather than biomedical/service-centred models of care (May, Finch et al. 2011). A good ALTS business model should adopt a policy to use only elderly friendly devices as this is the only way to make new technology quickly and widely accepted by the users (Lin, Liu et al. 2010). ALTS innovations should complete and consolidate the health and social care systems by allowing a continuum of care based on patient needs (Pare, Moqadem et al. 2010).</p>	(Madera A and A. 2004, Ackerman, Filart et al. 2010, Lin, Liu et al. 2010, Pare, Moqadem et al. 2010, Visser, Bloo et al. 2010, May, Finch et al. 2011).
Product innovation & commercialisation	According to Lin et al, the true test of an innovation lies in whether it could provide new value for users and the general public and this should apply to the ALTS innovation, such that it can be tested in the market to demonstrate that it is possible to sustain and can provide a new value proposition to its end users (Lin, Liu et al. 2010). In the development, marketing, adoption, and implementation of these tools and technologies, communication, training, cultural sensitivity, and end-user customization are critical pieces to the process (Ackerman, Filart et al. 2010).	(Lin, Liu et al. 2010, Visser, Bloo et al. 2010).
Infrastructure management	<p>According to Visser et al in (Visser, Bloo et al. 2010), the technology consists of a secured Internet Web-based application, standard personal computer, broadband Internet connection, and a digital camera. It must bring together the four domains that make up a business model, that is, service, technology, organization, and finance, and covers the integration of these domains.</p> <p>Next-generation tools and technologies are vehicles toward personalized medicine and these include cell phones and Internet-based telecommunications tools for remote and home health management with video assessment, remote bedside monitoring, and patient-specific care tools with event logs, patient electronic profile, and physician note-writing capability (Seror 2002, Ackerman, Filart et al. 2010).</p> <p>In managing ALTS infrastructures, important steps include: (1) understanding how the organization delivers care; (2) analysing the alternatives, including cost-benefit analysis; (3) obtaining organizational support; (4) formulating an execution plan; (5) training staff and monitoring the process (Pak 2005).</p>	(Seror 2002, Pak 2005, Pare and Trudel 2007, Ackerman, Filart et al. 2010, Visser, Bloo et al. 2010).
Customer relations management	A good ALTS business model is expected to deliver 24/7/365 call service provided by experienced health and care personnel (Lin, Liu et al. 2010). With respect to the patients targeted by home telemonitoring programs, it needs to be determined whether home telemonitoring is suitable to everyone (Pare, Moqadem et al. 2010).	(Cavallerano and Aiello 2005, Lin, Liu et al. 2010, Pare, Moqadem et al. 2010)
Financial viability and sustainability	Financial reimbursement for the service delivery is expected to be most successful when set up through healthcare insurance companies (Visser, Bloo et al. 2010). Medical technology companies developing ALTS products have to consider the market needs, the customer, the product development aspect, the business model, and the long process of market penetration, in order to choose the commercially correct idea and successfully bring it to the market (Zeevi 2003). A self-sustaining business model balances the cost and value associated with each ALTS activity (Gamble, Savage et al. 2004).	(Zeevi 2003, Gamble, Savage et al. 2004, Visser, Bloo et al. 2010)
Stakeholder credibility	<p>The stakeholders of ALTS identified in (Ackerman, Filart et al. 2010) include patients, patient communities, research funders, researchers, healthcare services providers, professional societies, industry, healthcare management/economists, and healthcare policy makers. Also, legal and regulatory issues need to be adequate addressed (Weinstein, Graham et al. 2009).</p> <p>It is expected that various actors other than those involved in traditional care are involved and need to cooperate, to deliver these services (Leff and Burton 2001, Visser, Bloo et al. 2010). This is because implementation of the video teleconsult service requires multidisciplinary cooperation and integration.</p> <p>Home telemonitoring application must be designed and implemented with the understanding that it is a complementary intervention and not a solution that replaces primary care (Pare, Moqadem et al. 2010). The American Telemedicine Association (ATA) in cooperation with the US National Institute of Standards and Technology stated that, the guiding principle is that it would be inappropriate to use telemedicine to provide anything less than the accepted standard of clinical care (Cavallerano and Aiello 2005).</p>	(Leff and Burton 2001, Cavallerano and Aiello 2005, Weinstein, Graham et al. 2009, Ackerman, Filart et al. 2010, Pare, Moqadem et al. 2010, Visser, Bloo et al. 2010)
Revenue Streams	Pricing needs to account for the fee of healthcare professionals as well as for technical aspects, education, and future innovation (Visser, Bloo et al. 2010). The model may also charge users directly and not through the national health insurance system (Barker, Krupinski et al. 2005, Lin, Liu et al. 2010).	(Barker, Krupinski et al. 2005, Lin, Liu et al. 2010, Visser, Bloo et al. 2010).

Table showing framework of sustainable business models for ALTS in the digital economy. It highlights the expected qualities for each of the business model components (Osterwalder and Pigneur 2009) discussed in Section 1.1 in order to make the business models workable and sustainable.

## 7 Conclusion

Through a comprehensive review of existing studies on assisted living, we have identified current trends in digital economy as they relate to ALTS. We investigated and categorised various segments of assisted living market. Also, various factors responsible for failure of ALTS commercialisation are presented. Evidence from previous studies shows that all the past attempts to take ALTS innovations into the mainstream market in the UK have failed. Thus, with the aid of concepts from diffusion of innovation theory, we reviewed the business model frameworks as presented in different literatures to suggest conceptual business model frameworks (Figures 6, 7 and Table 9) that could make commercialisation of assisted living products and services more effective and sustainable.

Generally, statistics in this paper as evident in the published papers (outside the working papers and reports) show that there has been less research into the business models aspects of ALTS or its segments in the United Kingdom when compared to USA and since the country has a traditional health and social care systems with funding models that are entirely different from those of other countries, it is highly necessary to look into business models that could be sustainable, scalable and workable for the UK health system and possibly extendable to other countries.

Also, the review shows that scholars do not agree on the terms and definitions of various technologies and services of ALTS and their segments and thus on what their business models ought to be. This lack of consensus raises doubts concerning the usefulness of their empirical research and on the quality of research outcomes of these previous studies which include the data they collected and analysed, and also in terms of data evaluation approaches. Our research has explored this area with robust and holistic approach to ALTS and with clear definitions, examples and practical illustrations of each segment. Our research provides a comprehensive up-to-date literature review on ALTS and their commercialisation attempts and we have carefully documented the discrepancies and dissonances in the literature.

Our review and analysis show that ALTS has a promising future to enable government and healthcare providers cope with the increasing pressure of aging population. However, more empirical studies are required to shape this research area into a more impactful one and most especially in addressing the sustainability and scalability of the ALTS business models. Our analysis shows that conceptual articles marginally outnumber empirical studies, and most of the identified empirical studies often lack formal hypotheses and rigorous methods. Also, the absence of collaboration between ALTS entrepreneurs, medical and management scholarship implies a serious missed opportunity to develop theories and empirical studies that could shed light in providing workable solutions to the unsustainability of ALTS businesses and how to move the field forward in light of current challenges brought by the digital landscape and cost-cutting pressures. This paper identified critical themes worthy of investigation and then addressed related fields of research that could inform and enrich the ALTS entrepreneurship debate.

The four main segments of ALTS market identified through our review of previous research include: (1) telehealth; (2) telecare; (3) telemedicine; and (4) Digital participation services. Following on from the introduction of direct payments, since 2006 there have been policy moves to broaden the scope of individual budgets. Our review showed that the difficulty with estimating the value of the assistive living services market is compounded potentially by levels of informal care which is not easily measurable and also many assistive technologies rely on a service but it is hard to differentiate the separate value. Our review also shows that traditionally, the private market for ALTS within the UK is made up of small highly specialised companies. These SMEs can undertake multiple roles within the supply chain, both designing and manufacturing these products. Due to the small scale and specialised operations, there is little interoperability between products from different suppliers.

Furthermore, the critical review of literature reveals some perceived barriers or factors that have made ALTS market difficult to develop (Table 8). However researchers and

academicians agreed that these barriers and factors vary from one segment of ALTS to another. Hence, we expect that if solutions to these barriers are taken into consideration as suggested in this paper (Table 9) it will have positive impact on sustainability of ALTS market. The UK Department of Health TCES strategic briefing (DPH 2009c) shows that there is an increasing level of un-met demand for community equipment (as shown in Figure 5). This graph projects that with a reduction in the amount of state funded support and increasing demand, there will be an estimated 134% level of un-met demand for ALTS. Reasons for un-met demands have been identified to include (i) Fear of indeterminate cost (Marshall and Dixon 1996) (ii) Denial of condition (Ellis and Scarfe 2009) (iii) Scepticism from healthcare professionals (Goodwin and Clark 2010) (iv) Language barrier (Ellis and Scarfe 2009) and (v) Lack of guidance and support (DPH 2007, Alliance 2010, Focus 2010).

Generally, detailed review of previous studies shows that failure of successful deployment and commercialization of ALTS are primarily connected with the lack of sustainable business models and authors have premised the reasons behind these failures under different headings which could be summarily classified into five primary reasons; (i) Poor coordination; (ii) Lack of user centred design; (iii) Security and privacy concern; (iv) Poor integration of policy and practice; and (v) Small market size and cost effectiveness. These reasons are as summarised for each ALTS market segment in Table 8.

Our proposed sustainable and conceptual business model framework incorporates solutions to factors that were identified in previous studies as influencing commercialisation of ALTS projects (Table 9, Figure 6 and Figure 7). We refined the conventional business model frameworks (Osterwalder and Pigneur 2009) by combining it with factors discussed in previous studies as well as concepts from diffusion of innovation theory, thus resulting in the development of an integrated model for business sustainability (Table 9, Figure 6 and Figure 7). Our approach suggests that business model and diffusion of innovation theory are complements, not substitutes. That is, to achieve profitability, the product innovation aspects of ALTS BMs need to satisfy all the innovation diffusion characteristics as highlighted in DOI.

Our framework suggested that compelling “*relative advantage*” is the most important factor of the DOI characteristics that could motivate the elderly people to pay for eHealth innovations despite the freely available NHS services. Other crucial DOI characteristics are “*compatibility*” and “*complexity*”. While relative advantage and compatibility are positively correlated to the diffusion of eHealth/ALTS innovations, complexity is negatively correlated. This is because most elderly people did not grow up with advanced technologies and therefore tend to avoid complex eHealth technological innovations and gadgets.

In conclusion, ALTS might have important roles as part of a strategy for the management of long term conditions (or chronic diseases) and delivery of effective health and social care services to enable independent living for older people, however, the services will only become meaningful to the general public when the business models are sustainable such that they will provide mutual benefits for providers as well as the users. Ultimately, the successful business models will depend on the capacity to provide very quality (qualities identified in DOI theory) ALTS products and services to the customers at the least cost, high credibility to stakeholders and generate sustainable revenue streams to the service providers. The ALTS innovations will spread and the business becomes sustainable when they evolve to meet the needs of successive segments of the population (of potential ALTS users) in accordance with the diffusions of innovation theory. Our systematic review offers further avenues for further research in this area.

## 8 Future Research

Having suggested a conceptual framework for ALTS business models, we will test and attempt to validate the framework by embarking on case studies of relevant organisations and focus groups. We will embark on empirical research that will classify the assisted living technology and service market from the perspective of business models development. We will conduct series of facilitated workshops and focus groups consisting of main stakeholders in assisted living, including health and social care organisations, businesses, local governments,

policy makers, technology developers, service providers and user representatives. The workshops will be used both for developing classification and validation.

We will also articulate lessons for assisted living from international best practice in sustainable market development of new digital technologies and services. We will further explore barriers and facilitators for sustainable market development of ALTS. We will equally develop case studies to illustrate the success and failure of business models and market development in ALTS for dissemination.

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