Policy Scenarios for the Digital Inclusion in an Aging Society: an Agent-based Simulation

# POLICY SCENARIOS FOR THE DIGITAL INCLUSION IN AN AGING SOCIETY: AN AGENT-BASED SIMULATION


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**ABSTRACT**

ICTs are central to modern life and their importance is going to increase in the next future. At the same time, policy makers will have to face significant challenges regarding the process of innovation adoption and use because of the aging trend present among European societies. Indeed, old age results to be one of the most relevant factors affecting the exclusion from the information society. This paper aims to implement through a simulation environment a set of alternative policies which policy makers could carry out to promote equal digital opportunities in an aging society. This objective has been achieved combining agent-based modeling technique able to build-up different policy scenarios and statistical tools used to investigate the relationship between age and Internet diffusion in Piedmont Region (Italy). The simulation results show that the subjective perceptions of Rogers' innovation attributes related to policy scenarios exert a significant influence on the dynamics of the diffusion process among old age people. Furthermore, it emerges that old people could enhance their technological adoption propensity in the next future through the building-up of specific ICT infrastructures, the provision of training courses addressed to them as well as the establishment of Technological Centers located in meeting places for elderly people. In particular, the implementation through the simulation environment of training courses for elderly people is likely to be the most efficient policy that Piedmont policy makers could carry out to accelerate Internet diffusion process in the short term.



**KEYWORDS**

Policy, aging, diffusion of innovation, agent-based model, simulation, scenario.


## 1. INTRODUCTION

Information and Communication Technologies (ICTs) are increasingly used at work, in day-to-day relationships, to access everything from public services to culture and entertainment, and for community and political participation. Their pervasiveness and their importance has led the ability to proficiently use such technology as “the indispensable grammar of modern life” (Wills, 1999).
The diffusion of ICT in nearly every aspect of society has produced two major consequences:

- it has significantly increased and extended the importance of network externalities deriving from the use of compatible technologies by critical masses of users;

- it has contributed to make the competitiveness and equality of socioeconomic systems strictly dependent on their capacity to absorb innovation and fruitfully put it into practice.

However, not everybody fully benefits from these new tools and the divide seems particularly critical even in more developed countries with aging population and low education levels: for instance, 45% of the Italian population has never used Internet and about 90% of over 65 belongs to this class (Eurostat, 2010). The main reasons are: lack of access to equipment or networks, the limited accessibility of user-friendly technologies, motivation, limited skills (Ferro et al., 2010) and different generational attitudes to advanced technologies (Ferro et al., 2009).

Furthermore, as far as Internet technology is considered, there is still a problem of broadband access in many European countries. For instance, in Italy the share of households with broadband connections accounts for 49% (Eurostat, 2010).

Action is, thus, needed at all levels of government, from local to European, and across the private sector, with particular emphasis on promoting equal digital opportunities, avoiding new forms of exclusion, ensuring all parts of Europe can employ high-speed Internet access and making ICTs accessible to everyone. ICTs can reinforce social inclusion, offering new opportunities for many people currently excluded from today's society.

The research questions which arise from the present paper can be summarized as follows:

- How the subjective perceptions of Rogers' technological attributes that elderly people may exhibit towards a new technology could influence their own technological adoption propensity in the next future?
- What are the effects of the implementation of a specific set of alternative policies addressed to old age people on technological diffusion dynamics?

## 2. STATE OF THE ART

The European governments are developing policy initiatives in order to improve ICT uptake amongst the elderly (European Commission, 2007).

More specifically, some policy actions and attempts adopted by several European countries in order to bridge the digital divide between young and old people include the creation of information platforms, special infrastructures and barrier-free public websites to meet the needs of old age people (e.g. Germany, Austria, Bulgaria, Netherlands, United Kingdom, etc.) as well as the provision of basic PC and Internet courses for the elderly which could provide them basic computer and ICT skills and promote the spread of information technology knowledge towards that category of people who are less oriented to adopt new technologies (e.g. United Kingdom, Switzerland, Portugal, Finland, Denmark, etc.). Furthermore, other actions carried out to support senior citizens in their relationship with the use of ICTs concern the establishment of IT-drop-in for elderly citizens (e.g. Denmark), the presence of retirement clubs with Network platforms (e.g. Hungary), the organization of ICT-clubs organized by voluntary organizations as Seniornett, where seniors can get help and start learning how to use and utilize a PC and Internet, and the creation of a network of computer centers for the elderly, the so-called "computerias".

However, little has been written regarding the study of the consequences on the diffusion of innovation which could arise from the implementation - through specific simulation environments - of adequate policy interventions addressed to old age people in order to promote equal digital opportunities in the next future. As observed, "there have been a number of studies on complexity and management, but there has been limited work on modeling complexity for policy analysis and decision support" (Kim, 2007).

Analysing the literature dealing with the issue of digital divide, it emerges that the problem of digital exclusion involves, especially, the elderly as well as the unemployed and those with a low level of education (Norris, 2001). This problem does not depend strictly on the fact that old age people have developed their technical skills during the pre-Internet era whilst it seems reasonable to assume that old age people are, in general, more reluctant to adopt and use new technologies. Indeed, the next old age people's generation will

have Internet-oriented technological skills which could be not sufficient to find simple the use of a new technology of the future because of the decline in cognitive and physical faculties (Hanson, 2009).
Looking at the strand of literature which analyses the relationship between age and technological adoption in the work environment, it can be deduced that the 'fluid intelligence' ('the ability to perceive relationships independent of previous specific practice or instruction concerning those relationships') (Cattell, 1963) declines with age (Horn, 1975). Thus, older workers tend to experience greater difficulties when adapting to changes in the work environment and at least initially are likely to take refuge in methods with which they are familiar (Morris et al., 2000). In addition, older employees exhibit greater 'crystallised intelligence' in light of their superior experiential base (Cattell, 1963). This induces them to apply 'traditional' solutions to tasks where IT can find application, since the unlearning of old routines is for them problematic and expensive. These observations could explain the difficulties that old age people may encounter in adopting a new technology since the changes of cognitive domains over the time could appear unfamiliar to elderly people who can take refuge in old cognitive methods and routines.
In this context, it is important to figure out how old age people perceive the adoption of a new technology which, according to Rogers, could be characterized by five perceived attributes (relative advantage, compatibility, complexity, trialability and observability) which are able to explain from 49 to 87 percent of the variance in the rate of adoption of an innovation (Rogers, 2003). For this reason, the simulation - through an appropriate modeling technique - of determined policy scenarios related to Rogers' perceived technological attributes could be useful to have a better understanding of the relationship between the subjective perceptions of the attributes of a given technology among, for instance, elderly people and the diffusion dynamics of the considered technology. Regarding the modeling techniques to be employed for the aforementioned purposes, Agent-Based Models (ABMs) represent a powerful tool used to simulate social systems, to capture useful information about the world (Bonabeau, 2002) (Lempert, 2002) and to assist decision making process in condition of deep uncertainty enabling the study of social and policy systems. These simulation models allow the creation and building of several scenarios useful to study the impact and the consequences arising from the implementation of a different set of policy actions and enable to capture emergent phenomena of the real world through a bottom-up approach by building the behaviour of individual agents. More specifically, the agents consist of autonomous decision-making entities which interact according to a set of determined rules (Garcia, 2005) in dynamic (often nonlinear) ways (Berry et al., 2002) and are characterized by adaptability, flexibility and learning capacity (Conte, 2002).

The contribution that this paper intends to bring to the existing body of knowledge about diffusion of innovation and policy modeling is twofold:

- investigate Internet diffusion dynamics by age groups in an aging society in order to have a better understanding of the technological diffusion process within age classes both in terms of innovation and imitation;
- perform a dynamic assessment (through the simulation environment) of three policy scenarios to figure out how the subjective perceptions of old people towards a specific technology could influence their own ability to absorb innovation.

## 3. INTERNET DIFFUSION DYNAMICS BY AGE GROUP: THE CASE OF PIEDMONT REGION

In order to investigate the relationship between age and Internet diffusion dynamics, the case of Piedmont Region has been considered since Piedmont is one of the largest Italian regions with a relatively high old-age dependency ratio. In particular, the number of elderly people aged 65 and over reached the 40,87% in 2010 compared to the number of people of working age (15 to 64) (Istat, 2010).
A specific survey has been devised, prepared and undertaken by Istituto Superiore Mario Boella with the collaboration of Politecnico di Torino in order to obtain the values of Rogers' technological attributes about how Piedmont citizens perceive the use of Internet technology. The questionnaire about technological

diffusion in Piedmont Region has been submitted both online and via telephone interviews to a sample of 180 Piedmont citizens through LimeSurvey, a free and open source survey software tool. The questions addressed to Piedmont citizens aim at investigating their technological perceptions towards Internet adoption and use. It is been used a Likert scale ranging from 1 (strongly disagree) to 10 (strongly agree) to indicate a state of disagreement or agreement with the survey's statements. The details about the measures included in the questionnaire submitted to Piedmont citizens as well as the descriptive statistics used for the analysis of the responses will be presented in another paper.
Analyzing Internet penetration data in Piedmont Region by age group from 1992 to 2009 (Figure 1), we can observe how the proportion of elderly Internet users on the total of population is currently low whilst Internet penetration rate for the younger age cohorts accounts for middle-high values. This situation depicts the current digital divide between young people and elderly people and we wonder what are the effects that specific policy interventions, addressed to old people in order to enable their digital inclusion - could have on technological diffusion dynamics.

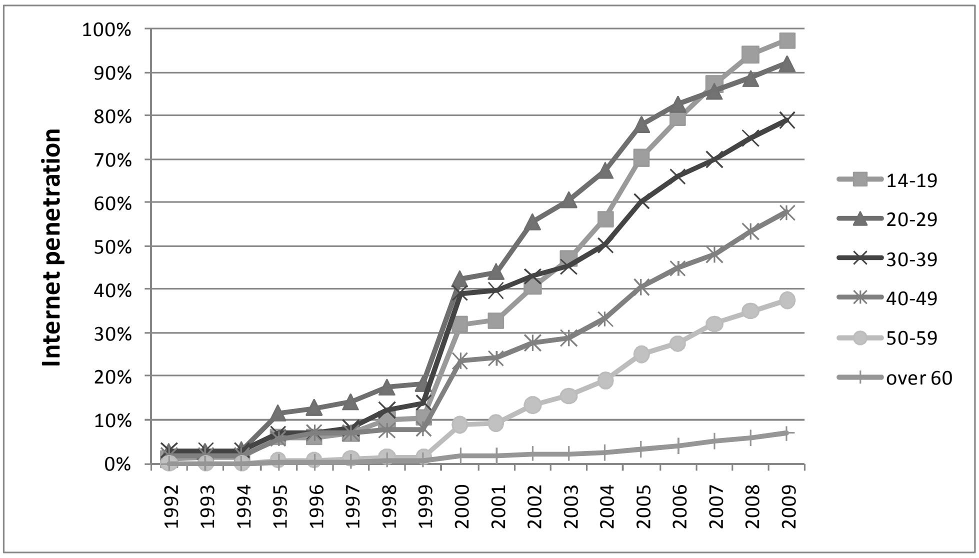


**Fig. 1.** Internet penetration by age group, 1992-2009 (source: survey conducted by Istituto Superiore Mario Boella in collaboration with Politecnico di Torino, 2010)

Furthermore, interesting observations may arise from the analysis of the Bass model parameters of the diffusion curves for each age group (Table 1). The aforementioned innovative (p) and imitative (q) parameters have been estimated through a non linear regression model applied to Internet penetration data in Piedmont from 1992 to 2009.

**Table 1.** Estimation of Bass parameters for each age group

| | Innovation parameter (p) | Imitation parameter (q) |
|---|---|---|
| 14 - 19 | 0.0029 | 0.4154 |
| 20 - 29 | 0.0084 | 0.3434 |
| 30 - 39 | 0.0108 | 0.2446 |
| 40 - 49 | 0.0091 | 0.1819 |
| 50 - 59 | 0.0030 | 0.2168 |
| over 60 | 0.0005 | 0.1893 |

In general, the influence of each individual's social network is likely to have a stronger impact on the diffusion of Internet technology rather than the mass media effect.
Entering into details, the word of mouth process would have positively affected Internet penetration rate especially among the younger cohorts (e.g. people aged 14-19).
Regarding over 60 Piedmont citizens, both innovation and imitation parameters account for low values.

# 4. AGENT-BASED SIMULATION MODEL

The Agent-Based Simulation model allows us to cope with the effects of an aging population on the diffusion of Internet technology relying on demographical data coming from Istat database (Istat, 2010) and enabling to simulate the adoption rate of a new technology. It allows to recreate at macro-level the Bass diffusion mechanisms and, at the same time, it enables to shape the individual behaviour of each agent.
The population devised in the model is divided by six age groups (14-19; 20-29; 30-39; 40-49; 50-59; over 60) where each agent belongs to a specific Rogers' adoption category (Innovators, Early Adopters, Early Majority, Late Majority, etc.) depending both on the time of the adoption and on the value of penetration of the technology itself.
The state variable of the dynamic system is represented by each agent's attitude to adoption $0 < Aj(t) < 1$, that could be interpreted as the utility that agent 'j' perceives to gain at time 't' by adopting the technology. We suppose that the price of the technology is equal to 1, so that when $Aj(t) = 1$, the agent becomes an adopter. Heterogeneity in the population is represented by the distribution of this state variable across agents at the start of the simulation. Attitude to innovation can be correlated to physical location, thus emulating both populations in which different classes intermix and populations in which they are segregated.
The technology is characterized by Rogers' perceived attributes (e.g. relative advantage, complexity, trialability, etc.) which are able to explain from 49 to 87 percent of the variance in the rate of adoption of an innovation (Rogers, 2003). In particular, each agent has its own adoption propensity which is distributed according to a normal distribution centred in the average value of the aforementioned technological perceived attributes with a variance equal to 1. It is important to clarify that, aiming to calculate the average value of Rogers' perceived technological attributes, the perceived ease of use of the given technology has been taken into account instead of complexity so that each attribute may provide a comparable contribution with each other regarding the diffusion of innovation.
At each time step of the simulation, each agent is supposed, with a given probability, to be exposed to information coming from a technology supplier and to information coming from other agents picked at random from the population, who may already be adopters of the technology. Such events lead to an increase in the attitude to adoption, until this variable eventually exceeds the price of the technology, which transforms a non-adopting agent into an adopter. Further parameters considered in the model are probability of innovation and probability of imitation, that represent the odds of being influenced either through the exposure to an innovative or imitative event, respectively.

# 5. SIMULATION OF THREE POLICY SCENARIOS

Three policy scenarios have been devised and developed through the Agent-based Modelling technique with the objective to provide useful advices for policy makers who intend to carry out specific policy interventions enabling the widest digital inclusion:

- *Scenario 1*: development of specified ICT infrastructures such as more user-friendly Web portals which can be simply used by old people;
- *Scenario 2*: training courses to teach old people the basic technological functionalities necessary to use PCs and to surf the Internet for simple tasks;
- *Scenario 3*: creation of Technology Centers placed in meeting places for senior citizens, for instance clubs for the elderly.

We have not implemented any policy scenario represented, for instance, by the provision of incentives (e.g. advantageous prices and discounts of PCs and ICT devices for elderly) because - as it emerges from the survey's responses of Piedmont citizens - senior people who are not Internet users do not consider the price of technology like an indispensable variable that prevents them from adopting the technology itself.
In order to build-up the policy scenarios previously described, the variables which have been taken into account to model the distribution of adoption propensity of each agent are represented by Rogers' perceived attributes of Internet technology in Piedmont. In particular, we have focused on the survey's responses of over 60 Piedmont citizens belonging to Late Majority adoption category to figure out how they consider and perceive Internet technology according to Rogers' diffusion of innovation theory.
The identified policy scenarios are based on the following assumptions:

H1. *The development of barrier-free web portals for elderly people is likely to have an influence on two specific technological attributes, the perceived relative advantage and ease of use of the given technology;*

H2. *The organisation of training courses for elderly people is likely to have an influence on the perceived relative advantage, ease of use, observability and trialability of the considered technology;*

H3. *The creation of technological centres in meeting places for the elderly is likely to have an influence on the perceived relative advantage, trialability and observability of the determined technology.*

Once adequately calibrated the simulation model's parameters through the Genetic Algorithms in order to minimize the deviation between empirical and simulated Internet penetration data for over 60 Piedmont citizens, it has been carried out a specific plan of experiments (Table 2). We have focused our attention on the following contexts:

- The case of no policy implementation which simulates what will happen in the next future regarding Internet penetration rate among over 60 Piedmont people using the data - obtained through the survey's responses - about the normalised average values of perceived attributes of Internet technology for over 60 Internet users ranging from 0 (the minimum value) to 1 (the maximum value);
- The case of policy implementation for each policy scenario represented by an increase of the values of those specific perceived technological attributes which characterize each specific scenario according to the aforementioned assumptions.

**Table 2.** Average values of perceived technological attributes of Internet technology for over 60 Piedmont Internet users belonging to Late Majority

| | Relative Advantage | Ease of use | Observability | Trialability |
|---|---|---|---|---|
| Case of no policy implementation | 0.90 | 0.73 | 0.85 | 0.50 |
| Scenario 1 | 0.95 | 0.78 | 0.85 | 0.50 |
| Scenario 2 | 0.95 | 0.78 | 0.90 | 0.55 |
| Scenario 3 | 0.95 | 0.73 | 0.90 | 0.55 |

For each scenario, ten multiple runs have been launched in order to reduce the model's variability and to obtain more reliable simulation results.
Simulation results (Figure 2) show how the subjective technological attributes of a determined technology, in our case Internet technology, among over 60 Piedmont citizens exert an influence on the dynamics of the diffusion process.

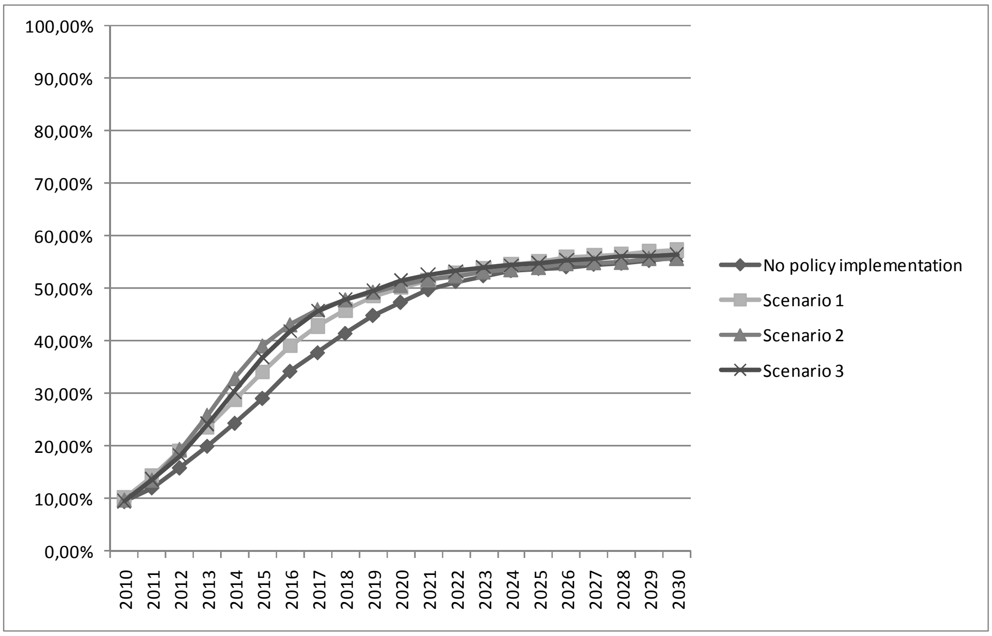


**Fig. 2.** Simulation of Internet penetration rate among over 60 Piedmont citizens both in case of no policy implementation and in case of implementation of three policy scenarios

In order to boost the diffusion of a new technology among, for instance, old age people, it seems to be fundamental to figure out how they perceive the adoption of the technology itself.

By building-up specific ICT infrastructures (scenario 1), old people could increase their technological adoption propensity because of a greater perceived usefulness and ease of use emerging from the possibility to access to several online services specifically focused on their needs through a simple and user-friendly web portal.

Furthermore, elderly people could be less reluctant to use a new technology (scenario 2) thanks to the provision of specific training courses allowing them to learn the basic technological functionalities.

They could use a technological device never used before or benefit from the observation of their classmates' habits and methods of using the considered technology.

In addition, senior citizens could enhance their technological adoption propensity (scenario 3) thanks to the establishment of Information Centers located, for instance, in clubs for the elderly able to provide the possibility to access to Internet technology representing either a chance to experiment the use of a new technology in a trial-way before becoming adopters of the technology itself or a worthwhile meeting place where they could confront with other people observing how they use a given technological device.

The simulation results point out, also, how the implementation of the identified policy interventions could accelerate the technological diffusion process in the short term. In particular, the implementation through the simulation environment of training courses for elderly people is likely to be the most efficient policy that Piedmont policy makers could carry out in the next future to accelerate Internet diffusion process. However, the technological gap between young and old people could be still present in the long term even if to a lesser degree than today's. Indeed, in 2030 according to the agent-based model's results, Internet penetration rate could account for less than 60% whilst the other age cohorts could have already reached the saturation of technological diffusion. This situation which may occur in the next future is mainly due to the low values of innovative and imitative parameters (Table 1) characterizing over 60 Piedmont citizens compared to the other younger age cohorts.

# 6. CONCLUSIONS

This paper aims at better investigating the relationship between age and technological diffusion dynamics on the one hand and it permits to analyze the effects of the implementation (through a simulation environment) of a set of alternative policy scenarios for the digital inclusion of old people on their ability to adopt a new technology on the other hand.
For this purpose, the case of Piedmont Region has been taken into account since Piedmont is one of the largest Italian regions with a relatively high old-age dependency ratio. Concerning Internet diffusion dynamics, it can be observed the current digital divide between young people and old people (Figure 1), which local policy makers will have to face in the next future.
Interesting observations may arise from the analysis of the estimates of Bass model parameters (Table 1) of Internet diffusion curves by age group in Piedmont. In general, the influence of each individual's social network is likely to have a stronger impact on the diffusion of Internet technology rather than the mass media effect.
Simulation results (Figure 2) about the three policy scenarios we have implemented through the agent-based modeling technique show that the subjective technological attributes of a determined technology, in our case Internet technology, among over 60 Piedmont citizens exert an influence on the dynamics of the diffusion process.
More specifically, by building-up specific ICT infrastructures (scenario 1), old people could increase their technological adoption propensity because of a greater perceived usefulness and ease of use emerging from the possibility to access to several online services specifically focused on their needs through a simple and user-friendly web portal.
Furthermore, elderly people could be less reluctant to use a new technology (scenario 2) thanks to the provision of specific training courses allowing them to learn the basic technological functionalities.
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Further research will be necessary to carry out a cost-benefit analysis in order to calculate both the costs and the utility arising from the implementation of policy interventions.

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