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Heterogeneity and dissemination of the digital economy: the case of Spain

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Contents

Introduction

The study of the process of this phenomenon can be conducted on either the supply or the demand side

On the supply side, innovation is one of the main pillars underpinning economic growth in countries (Schumpeter, 1910; Romer, 1995)

On the demand side, there is an abundance of literature, basically in the context of marketing, that develops the theories of technological dissemination (Bass, 1964; Rogers, 1995)

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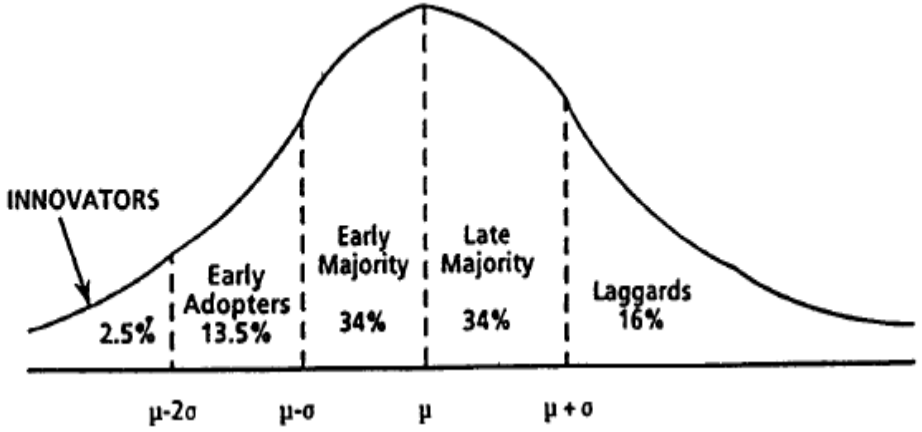
Life-cycle and dissemination of ICT innovations

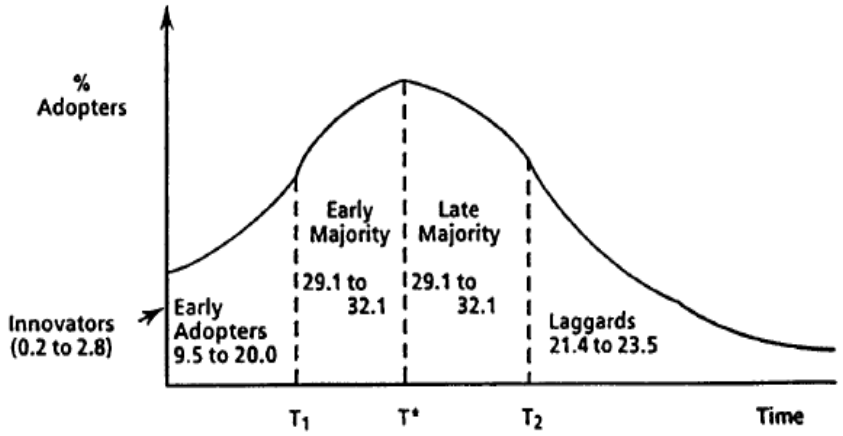
The theories of technological dissemination

The speed at which a population adopts a technology depends on two main parameters: p, which determines its innovative character, and q, which is its imitative character ("word of mouth")

Rogers' dissemination process (1995)



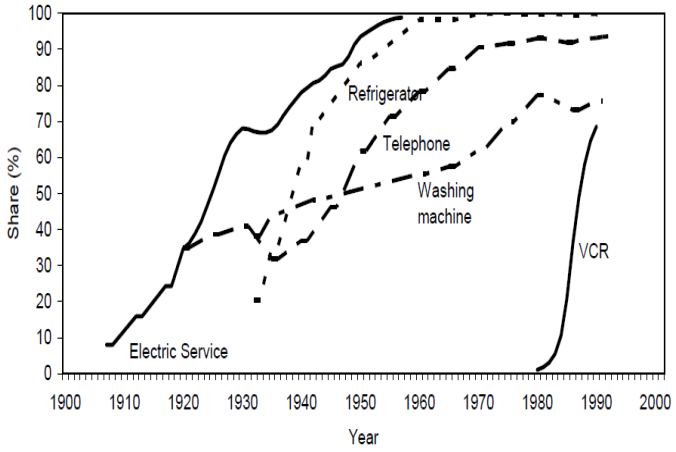
Bass' dissemination process (1964)

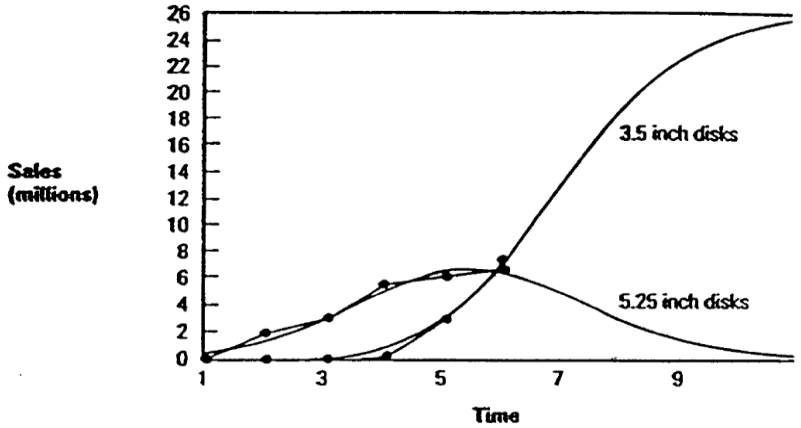


Life-cycle and dissemination of ICT innovations

The theories of technological dissemination

Dissemination of the main innovations in USA





The different values of p and q determine the speed and the extent to which a technology is adopted

The appearance of a replacement technology can affect the adoption dynamics

Life-cycle and dissemination of ICT innovations

The theories of technological dissemination

- The theories of technological dissemination show how and why a technology is adopted for use by a society
- The Bass model (1964) is a benchmark that has acted as the foundation for many later works

$$\frac{dN(t)}{dt} = [p + qN(t)][N - N(t)]$$

Where:

$\frac{dN(t)}{dt}$	is the speed of dissemination at moment t
$N(t)$	is the total number of adopters until moment t
N	is the total number of potential adopters in the market
p	is a constant associated with the innovative character of the population
q	is a parameter associated with the imitative character of the population

Life-cycle and dissemination of ICT innovations

Decisive factors of technological dissemination (Rogers, 1995)

Attributes that influence potential adopters of an innovation

- The relative advantage of the innovation
- Its compatibility with the current way of doing things and with the social norms of the potential adopter
- The complexity of the innovation
- The ease with which the innovation can be tested by a potential adopter
- The ease with which the innovation can be assessed after testing
- **Socio-demographic factors: education, age, income etc.**

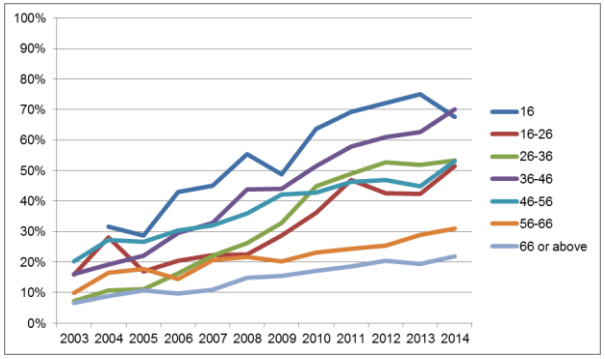
External or social conditions that can accelerate or delay the process

- Whether the decision is taken collectively, by individuals or by a central authority
- The channels of communication used to obtain information about an innovation, be they mass media or interpersonal channels
- The nature of the social system that potential adopters form part of, its norms and the degree of interconnection
- The importance of the agents of change (advertisers, development agencies etc.)
- Promotion efforts

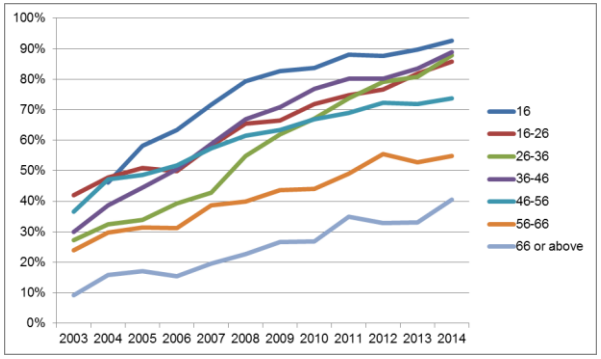
Life-cycle and dissemination of ICT innovations

Empirical evidence observed: % of population that has the internet at home by generation

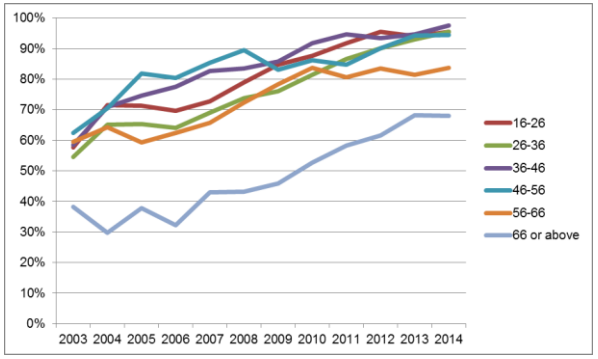
Primary education



Secondary education



University education



Growing trend towards adopting internet by all generations

Younger generations with a higher level of education start at a higher level and attain higher adoption percentages for those using internet

The population cohort effect is less evident among those with a university education

Life-cycle and dissemination of ICT innovations

Working objectives

Questions to answer:

Introduce heterogeneity in the Bass model (life-cycle, education, population cohort)

Estimate p and q for each different ICT (internet, electronic commerce, electronic banking) in the case of Spain

Can a change of inter-generational type modify the coefficients of national innovation and imitation over the long term?

Contents

Database

INE survey

Survey on Equipment and Use of ICTs in Households, conducted by INE (Spanish National Statistics Institute)

Study period: 2003-14

Variables of interest:

- Internet use
- Electronic commerce use
- Electronic banking service use

Database

Kinds of consumers

Groups of consumers by age and level of education in 2003

Group	Age group	Level of education
1	16 - 18	Secondary
2	18 - 25	University
3	16 - 64	Primary or less
4	19 - 64	Secondary
5	26 - 64	University
6	Over 64	Primary or less
7	Over 64	Secondary
8	Over 64	University

Database

Information about consumers

Based on this classification, age limits are moved from one year to another. We intend to monitor generations of individuals this way

Using a similar argument to Correa et al, (2015) and Pérez-Hernández and Sánchez-Mangas (2011), the target population is filtered with an ICT adoption process tree

People who use e-commerce and/or digital banking services have first to state that they have used the internet

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Econometric model

Assumptions and structures

Adoption over time distribution function F(t), such that F(0) = 0 and f(t) is the associated density function

Central proposal of the Bass model: the probability of adoption at a moment in time t, given that adoption has not yet occurred [f(t)/(1-F(t))], is equal to parameter p (innovation coefficient) plus parameter q (imitation coefficient) multiplied by F(t), the accumulated fraction of people who adopt the technology in a moment of time t:

$$f(t)/(1-F(t)) = p + qF(t)$$

Econometric model

Assumptions and structure

Additional assumption: F(t) = mN(t), where m is another parameter of the model (related to the maximum number of people who can potentially adopt) and N(t) shows the accumulated number of people who adopt in period t

The modelling process (Mahajan et al,1995; Kijek and Kijek, 2010) suggests several proposals for estimating the Bass model. Two of these are followed in this case: OLS (Ordinary Least Squares) and NLS (Nonlinear Least Squares)

Econometric model

OLS estimate

The OLS option is based on a discrete time version of the previous equation:
$N(t) - N(t-1) = \beta_0 + \beta_1 N(t-1) + \beta_2 N^2(t-1) + u(t)$

$u(t)$ is the model disturbance

The model parameters (β_0. β_1. β_2) are related to the terms of the Bass model:
$\beta_0 = pm$. $\beta_1 = (q - p)$. $\beta_2 = - q / m$

The number of periods (t) goes from 2003 to 2014

It generates results that are **inconsistent** with the significance of the parameters

Econometric model

NLS estimate

NLS is based on the original formulation of the Bass model:

$$N(t) - N(t-1) = \frac{m - \frac{p(m-N_0)e^{-(p+q)t}}{p+\frac{q}{m}N_0}}{1+\frac{\frac{q}{m}(m-N_0)e^{-(p+q)t}}{p+\frac{q}{m}N_0}} - \frac{m - \frac{p(m-N_0)e^{-(p+q)(t-1)}}{p+\frac{q}{m}N_0}}{1+\frac{\frac{q}{m}(m-N_0)e^{-(p+q)(t-1)}}{p+\frac{q}{m}N_0}} + u(t)$$

P and q can be estimated directly

N_0 is the accumulated number of people who adopt from the start

The values obtained with the OLS estimate are set as initial values for the NLS estimate

Contents

Results of the econometric model

NLS results: internet use

	16-18 Secondary	18-25 University	16-64 Primary	19-64 Secondary	26-64 University	> 64 Primary	> 64 Secondary	> 64 University	Total
p	0.048***	0.022***	0.009**	0.019***	0.025***	0.000***	0.000***	0.023***	0.022***
	(0.004)	(0.001)	(0.004)	(0.003)	(0.003)	(0.000)	(0.000)	(0.008)	(0.002)
q	0.133***	0.193***	0.320***	0.114***	0.082***	0.095***	0.071***	0.092**	0.121***
	(0.035)	(0.016)	(0.055)	(0.020)	(0.016)	(0.020)	(0.011)	(0.043)	(0.013)

Innovation is clearly associated with lower age/higher level of education

There is a less-defined pattern (in age and education) with imitation

Results of the econometric model

NLS results: e-commerce

	16-18 Secondary	18-25 University	16-64 Primary	19-64 Secondary	26-64 University	> 64 Primary	> 64 Secondary	> 64 University	Total
p	0.016***	0.013***	0.007**	0.012***	0.016***	0.000	0.009	0.014**	0.013***
	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.000)	(0.005)	(0.007)	(0.002)
q	0.259***	0.272***	0.412***	0.220***	0.187***	0.155	0.494***	0.171**	0.222***
	(0.053)	(0.035)	(0.061)	(0.036)	(0.045)	(0.104)	(0.113)	(0.085)	(0.036)

Innovation is associated with lower age/higher level of education (middle-aged population plays a more leading role)

Less innovation and more imitation than for internet use

Results of the econometric model

MCNL results: e-banking

	16-18 Secondary	18-25 University	16-64 Primary	19-64 Secondary	26-64 University	> 64 Primary	> 64 Secondary	> 64 University	Total
p	0.011***	0.008***	0.003	0.005*	0.010**	0.000*	0.009	0.028***	0.009***
	(0.004)	(0.001)	(0.005)	(0.003)	(0.004)	(0.000)	(0.006)	(0.010)	(0.001)
q	0.312***	0.309***	0.406***	0.142***	0.104***	0.025	0.190*	0.109	0.160***
	(0.071)	(0.014)	(0.080)	(0.021)	(0.019)	(0.056)	(0.110)	(0.074)	(0.013)

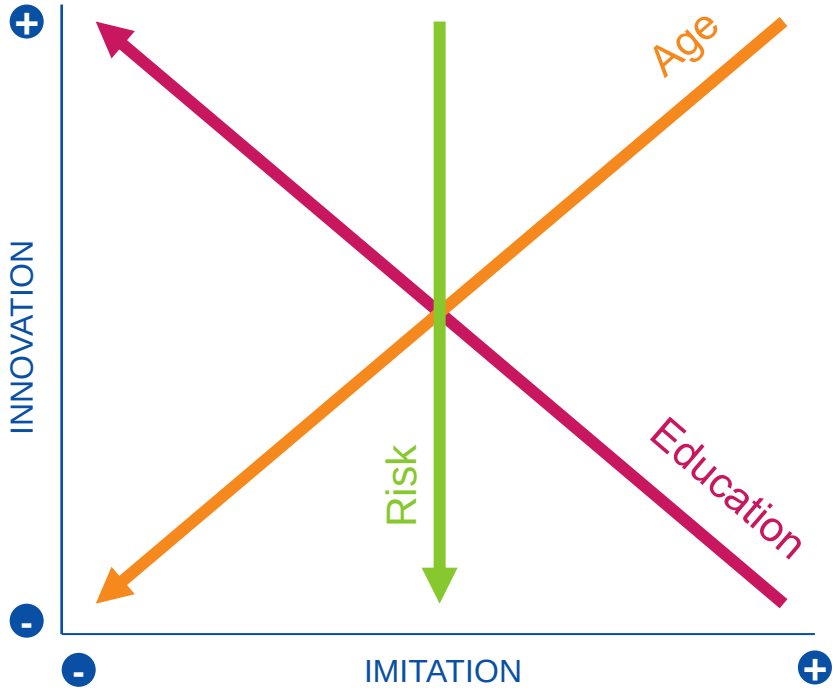
Innovation is associated with lower age (to a lesser extent)/higher level of education

Less innovation and more imitation than with internet use

Results of the econometric model

General results

Age, education and risk



Innovation increases with level of education and decreases with age

Imitation decreases with level of education and with age

Innovation decreases when the product includes a component of risk or requires specific knowledge to use it (financial experience)

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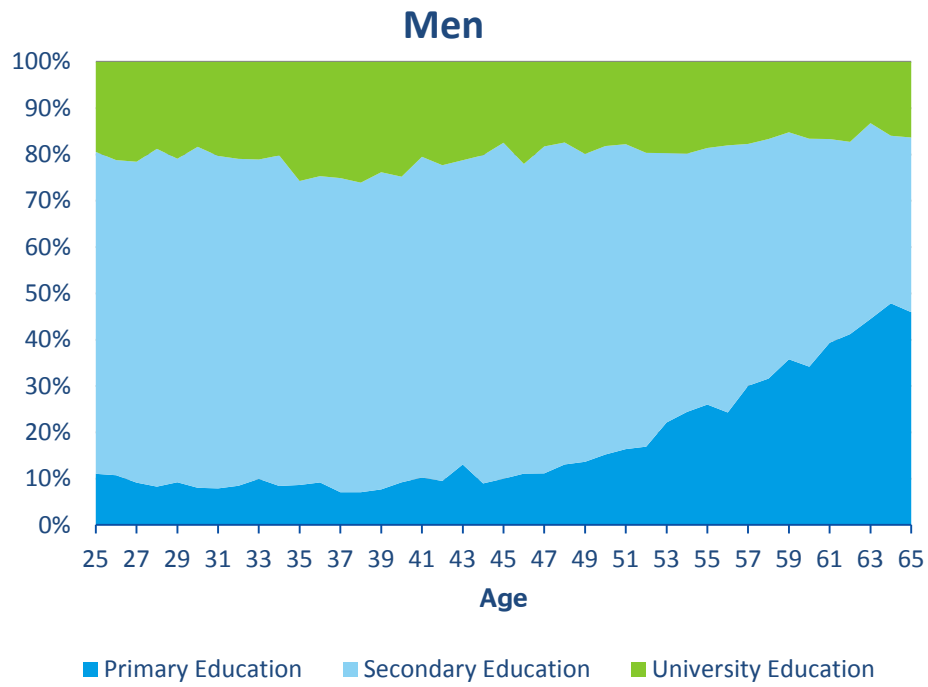
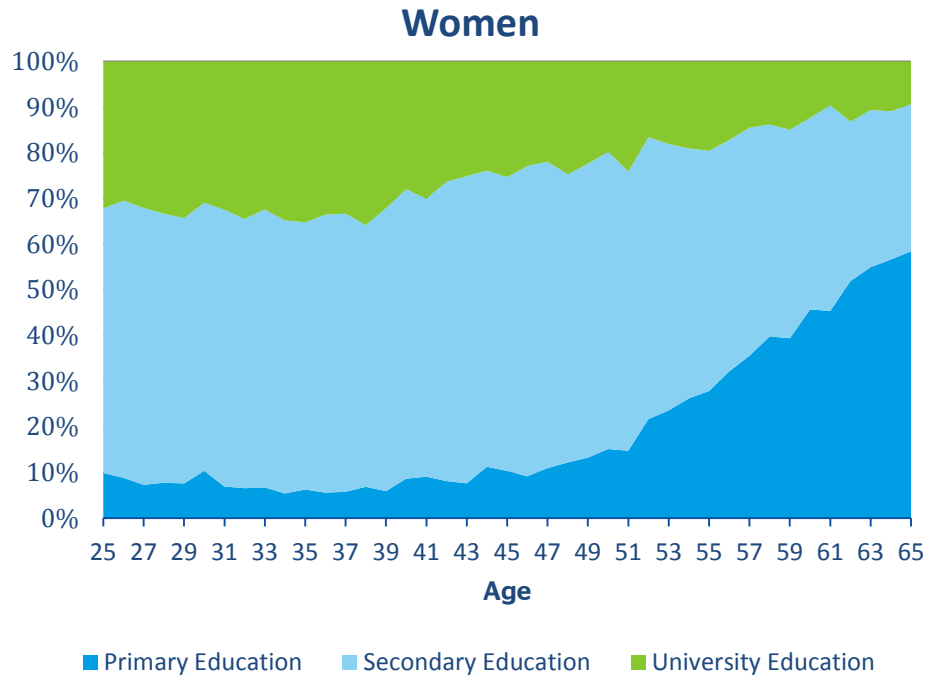
The dynamics of socio-demographic transition

Transition of level of education in Spain

Population distribution by gender, age and level of education (2012)

Source: EPA – INE

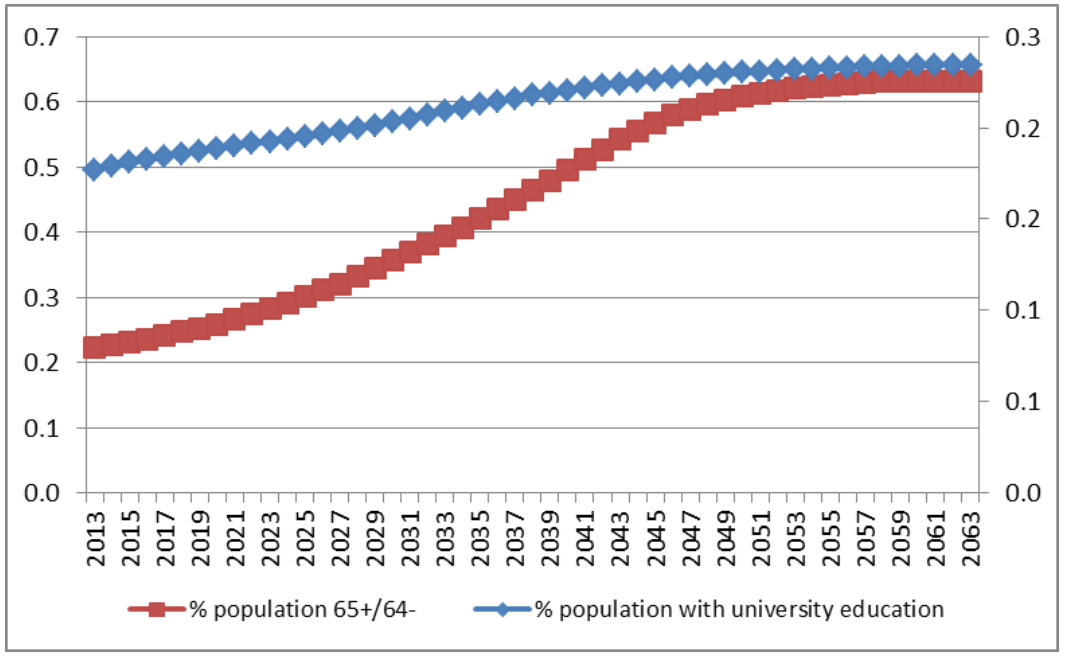




The dynamics of socio-demographic transition

E-commerce and e-banking forecasts in Spain

The population dynamics (ageing population) could change the innovative or imitative character of a country; in other words, global variables p and q can evolve over time



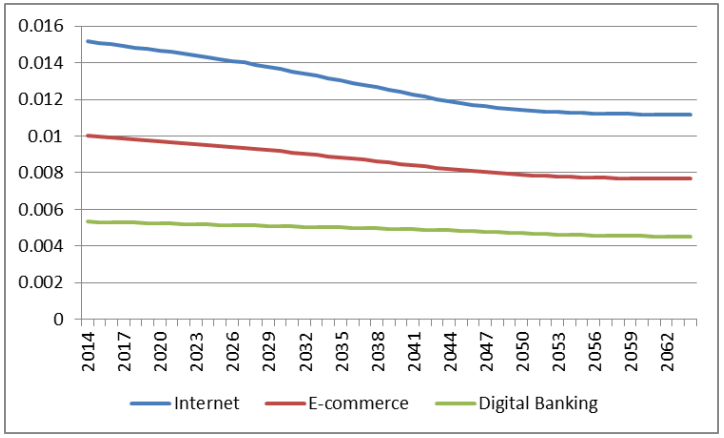
Source: INE

The dynamics of socio-demographic transition

Effects of socio-demographic transition in Spain

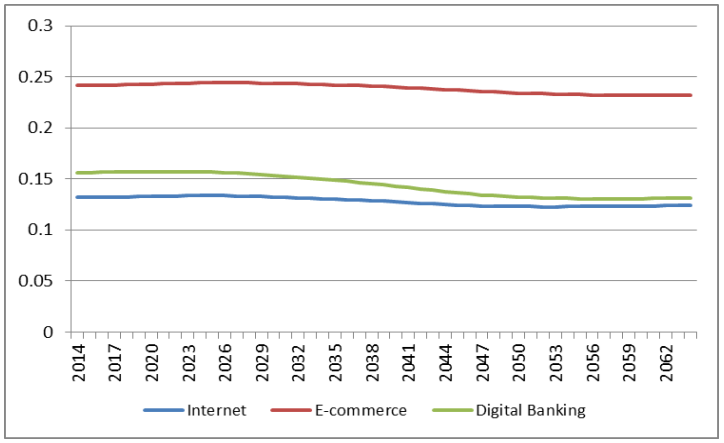
Tendency effect of ageing population on innovation coefficient (p)

Source: INE and the authors



Tendency effect of ageing population on imitation coefficient (q)

Source: INE and authors



The innovation coefficient falls 25pp in the dissemination of internet, 21.7pp in e-commerce and 12.7pp in digital banking

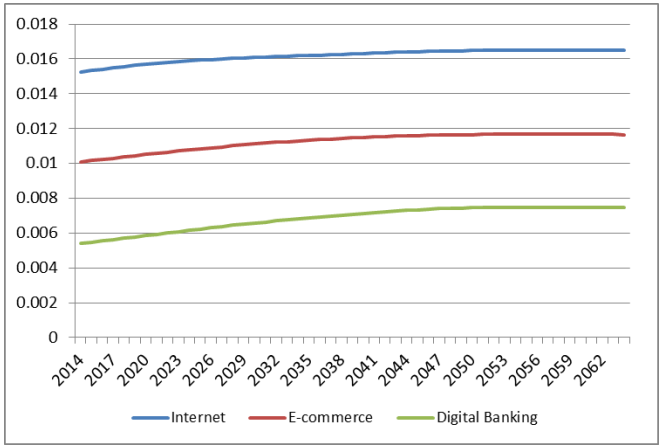
At the same time, the imitation coefficient decreases by 5.6pp, 2.8pp and 14.8pp respectively

The dynamics of socio-demographic transition

Effects of socio-demographic transition in Spain

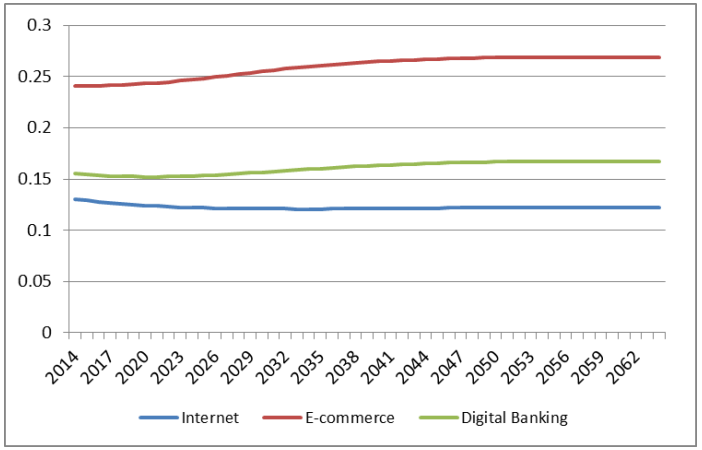
Tendency effect of improved education on innovation coefficient (p)

Source: INE and authors



Tendency effect of improved education on imitation coefficient (q)

Source: INE and authors



The innovation coefficient increases 8.1pp for internet dissemination, 15.7pp for e-commerce and 38pp for digital banking

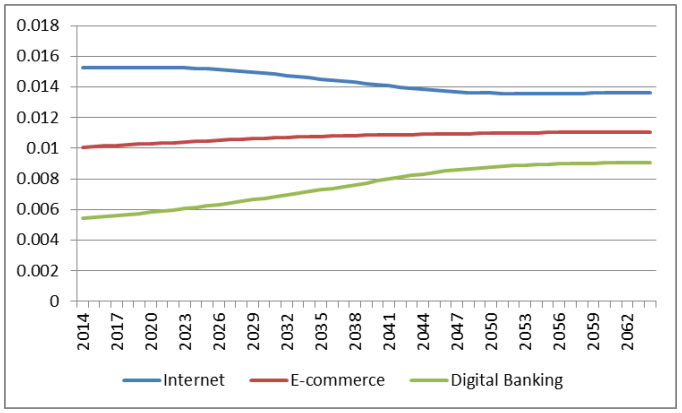
The imitation coefficient for internet decreases 6.4pp, while it increases 11.4pp for e-commerce and 7.4pp for digital banking

The dynamics of socio-demographic transition

Effects of socio-demographic transition in Spain

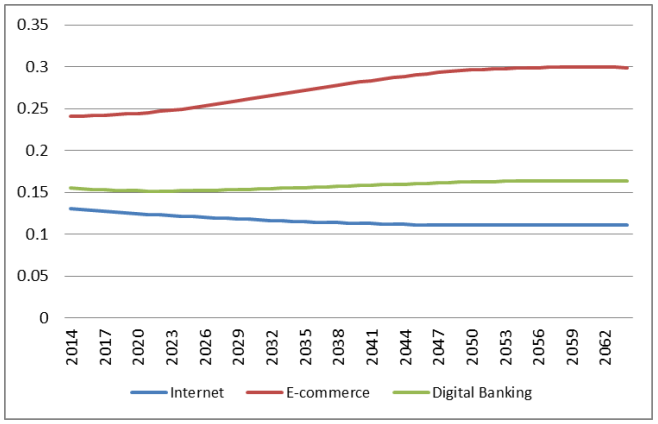
Combined tendency effect (education/ageing) on the innovation coefficient (p)

Source: INE and authors



Combined tendency effect (education/ageing) on the imitation coefficient (q)

Source: INE and authors



The innovation coefficient for internet decreases 10.8pp and the innovation coefficients for e-commerce and digital banking increase 8.9pp and 62pp respectively

The imitation coefficient decreases 15pp for internet use and increases 22.9pp and 4.6pp for e-commerce and digital banking

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Conclusions

In the future, the studies that underpin the Bass model could improve if they segment the target populations to control for heterogeneity

In the use of ICTs, the innovation coefficient increases with the level of education and decreases with the age of the individual

In the use of ICTs, the imitation coefficient decreases with the level of education and decreases with age in primary education. It is not well-defined for the other age groups

The innovation coefficient decreases proportionately with the risk component of the product consumed or with the need for specific knowledge to use it (financial knowledge)

Conclusions

The demographic dynamics of a country can have a major influence on its innovative character

The effects stemming from these dynamics are that we could see a gradual decrease in the dissemination tendency for internet use, while it could pick up in the case of e-commerce and digital banking use

It would be interesting to study the policies necessary to offset this tendency if the effects are negative