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Modeling the propagation of the consumption of two emergent businesses: Fitness Practice and Plastic Surgery

PhD THESIS
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Abstract

In recent years, there has emerged a new trend focused on the body image in the Western countries. Our society is concerned with people's physical appearance and ideal body image. As consequence of this trend, two businesses emerge: fitness centers and the plastic surgery clinics. Traditionally the consumer's expenditure in these services and goods has been considered a luxury especially during the economic slowdown. However, in the recent times, (at end of $2000s$ they are showing an increasing trend in terms of activity and business size). Thus, customers have seen the practice of fitness and plastic surgery procedures as a necessity rather than a luxury.

In this context,we find out people try to replace their well-being falling into loyalty consumers. In particular, under forty years old males increase their gym practice in order to improve their body image for both, their personal self-esteem and their sexual appeal. On the other hand, we have observed the emergence of plastic surgery practice between women due to the social pressure, ideal body image propagated by media and economic affordability of these procedures. As a results, the aim of this thesis consist of developing two discrete epidemiological mathematical models to study the aggregated behavior of population who practice fitness and also a second model for those who undergo plastic surgery procedures. The first part of the thesis focuses on forecasting the proportion of males' fitness consumption in Spain in the next years. Economic and psychological motivations are taken into account in order to quantify the dynamic behavior of men gym users.

The second part of the thesis is focused on the study of plastic surgery practice among women, a consumption that grows continuously in Western countries due to body image dissatisfaction, aging anxiety and the ideal body image propagated by media. The growth of plastic surgery consumption is so important that it is becoming a normal practice among women, like any other cosmetic product, with the risk of suffering psychopathology disorders in the sense that plastic surgery can be applied as an instrument to recover personal self-esteem, or even happiness.

In this framework, we develop an epidemiological mathematical model to forecast the female plastic surgery consumption in Spain. The main factors taken into account are economic, demographic and social ones. Once the model is fully constructed, popula-

tion of over-consumers is predicted and simulated. Then, the robustness of the model is studied. Finally, after modeling and simulating both models, results are discussed and conclusions of the thesis will be commented.

Resumen

En los últimos años se ha surgido, una nueva tendencia que se centra en la imagen corporal en los países occidentales. Nuestra sociedad tiene que ver con la apariencia física de las personas y la imagen corporal ideal. Como consecuencia de esta tendencia, dos negocios emergen: los gimnasios y las clínicas de cirugía plástica.

Tradicionalmente el gasto del consumidor en estos servicios y productos ha sido considerado un lujo, especialmente durante la desaceleración económica. Sin embargo, en los últimos tiempos, (al final de la década de 2000 están mostrando una tendencia creciente en términos de actividad y tamaño de la empresa). Por lo tanto, los clientes han visto la práctica de fitness y procedimientos de cirugía plástica como una necesidad más que un lujo. En este contexto, nos encontramos con personas que tratan de aumentar su bienestar cayendo en los consumidores de fidelidad de estos servicio. En particular, los adultos jóvenes de cuarenta años de edad, aquéllos que buscan aumentar su musculatura en gimnasio para mejorar la imagen de su cuerpo físico, por tanto, su autoestima personal y su atractivo sexual. Por otro lado, se ha observado la aparición de la práctica de la cirugía plástica entre las mujeres debido a la presión social, la imagen corporal ideal propagada por los medios de comunicación y la asequibilidad económica de estos procedimientos.

Como resultado, el objetivo de esta tesis consiste en desarrollar dos modelos matemáticos epidemiológicos sociales diferenciados para estudiar el comportamiento agregado de población que la práctica de fitness y un segundo modelo para aquellos que se someten a procedimientos de cirugía plástica.

El primero parte de la tesis se centra en los consumidores del gimnasio en España en los próximos años. Motivaciones económicas y psicológicas se tienen en cuenta con el fin de cuantificar el comportamiento dinámico de los usuarios de la sala.

La segunda parte de la tesis se centra en el estudio de la práctica de la cirugía plástica entre las mujeres, un consumo que crece continuamente en los países occidentales debido a la insatisfacción con la imagen corporal, el envejecimiento de la imagen personal ideal ansiedad y por los medios de comunicación.

El crecimiento del consumo de la cirugía plástica es tan importante que se está convirtiendo en una práctica habitual entre las mujeres, al igual que cualquier otro producto cosmético, con el riesgo de sufrir trastornos psicopatológicos en el sentido de que la cirugía plástica puede ser aplicada como un instrumento para recuperar la autoestima personal o incluso la felicidad. En este marco, se desarrolla un modelo matemático epidemiológico social para pronosticar el consumo de la cirugía plástica femenina en España.

Los principales factores que se tienen en cuenta son los económicos, demográficos y sociales. Una vez que el modelo está completamente construido, la población de mayores de los consumidores se predice y simuladas. A continuación, se estudia la robustez del modelo. Finalmente, después del modelado y la simulación de ambos modelos, los resultados son discutidos y las conclusiones de la tesis se comentarán.

Resum

En els últims anys s'ha sorgit, una nova tendència que se centra en la imatge corporal en els països occidentals. La nostra societat té a veure amb l'aparença física de les persones i la imatge corporal ideal. Com a conseqüència d'esta tendència, dos negocis emergixen: els gimnasos i les clíniques de cirurgia plàstica. Tradicionalment la despesa del consumidor en estos servicis i productes ha sigut considerat un luxe, especialment durant la desacceleració econòmica. No obstant això, en els últims temps, (al final de la dècada de 2000 estan mostrant una tendència creixent en termes d'activitat i grandària de l'empresa). Per tant, els clients han vist la pràctica de fitness i procediments de cirurgia plàstica com una necessitat més que un luxe.

En este context, ens trobem amb persones que tracten d'augmentar el seu benestar caient en els consumidors de fidelitat d'estos servicis. En particular, els adults jóvens de quaranta anys de edat aquells que busquen augmentar la seua musculatura en gimnàs per a millorar la imatge del seu cos físic, per tant, la seua autoestima personal i el seu atractiu sexual. D'altra banda, s'ha observat l'aparició de la pràctica de la cirurgia plàstica entre les dones degut a la pressió social, la imatge corporal ideal propagada pels mitjans de comunicació i l'assequibilitat econòmica d'estos procediments.

Com resultat, l'objectiu d'esta tesi consistix a desenrotllar dos models matemàtics epidemiològics socials diferenciats per a estudiar el comportament agregat de població que la pràctica de fitness i un segon model per a aquells que se sotmeten a procediments de cirurgia plàstica.

La primera part de la tesi se centra en els consumidors del gimnàs a Espanya en els pròxims anys. Motivacions econòmiques i psicològiques es tenen en compte a fi de quantificar el comportament dinàmic dels usuaris de la sala.

La segona part de la tesi se centra en l'estudi la pràctica de la cirurgia plàstica entre les dones, un consum que creix contínuament en els països occidentals degut a la insatisfacció amb la imatge corporal, l'envelliment de la imatge personal ideal ansietat i pels mitjans de comunicación.

El creixement del consum de la cirurgia plàstica és tan important que s'està convertint en una pràctica habitual entre les dones, igual que qualsevol altre producte cosmètic, amb el risc de patir trastorns psicopatològics en el sentit que la cirurgia plàstica pot ser aplicada com un instrument per a recuperar l'autoestima personal o inclús la felicitat.

En este marc, es desenrotlla un model matemàtic epidemiològic social per a pronosticar el consum de la cirurgia plàstica femenina a Espanya. Els principals factors que es tenen en compte són els econòmics, demogràfics i socials. Una vegada que el model està completament construït, la població de majors dels consumidors es prediu i simulades. A continuació, s'estudia la robustesa del model. Finalment, després del modelatge i la simulació d'ambdós models, els resultats són discutits i les conclusions de la tesi es comentaran.

Contents

List of Tables

List of Figures

List of publications

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Introduction

The physical body image consumption prevalence among the new generation of men and women has extended during last decades. The level of exercise increases physical fitness among men, also the procedures of plastic surgery has increased extremely among women, which can lead to health benefits and also has become a new style of life; however these practices in excess can loose psycho-medical diseases.

In particular, referred to the fitness practice business, this involves a parallel increase of related economic sectors such as sport clothing, energy drinks and sports equipment. Related to the Spanish population who exercise regularly, this has evolved from 27% in 2005 to 35% in 2010, which shows a significant increase of the population sportive practices. A significant example of this trend is the fact in 2009 the 74% of the Spanish public gyms had a fitness room for bodybuilding.

On the contrary, related to the market of plastic surgery measured by volume of activity, Spain occupies the level $12th$ position of the international ranking, which is headed by USA. The plastic surgery market embraces low invasive (non surgical) and high invasive (surgical) plastic surgery procedures; between both types, more than $300\,000$ procedures are performed annually mainly by women in Spain (SECPRE, 2006).

Taylor (1985) published the first study about the phenomenon in which men perceive their body as smaller. In 1993, Pope and colleagues (at the laboratory of Mclean Hospital's Biology Psychiatry) observed in their research that a significant number of body builders perceived themselves as small and thin. In addition, Pope et al., in1997 observed the regular practice of fitness produced the individuals become pathologically preoccupied with their level of muscularity causing them significant distress and functional impairment, what was associated in later studies with depression, social anxiety, self-esteems and social phobia, (Hitzeroth *et al.,* 2001).

In contrast, women show more interest than men towards the practice of plastic surgery procedures. Thus, plastic surgery is a medical phenomenon spread among the female (Eriksen and Goering, 2011). The attractiveness of physical appearance and stereotyped female body image pressure likewise augmentation or reduction of breasts, anti-aging

surgeries, rejuvenation and/or look for an ideal body pattern are becoming natural practices as any other consumption good in Western societies (Andreoni and Petrie, 2008; Smirnova, 2012); for instance, gym practices combined with diet foods and drinks are usually correlated with the consumption of aesthetic surgical practices.

Indeed, it is well known that a good image eases the professional promotion and social recognition. (Kvalem *et al.*, 2006; Sarwer *et al.,* 2005; Swami *et al.,* 2008; Swami *et al,* 2009a; Coughlin *et al.,* 2012).

Apart from these socio-biological factors (drivers) of continuous fitness practice and plastic surgeries we should also consider the social contagion effect propagated by marketing (Menzel *et al.,* 2011; Patil *et al.,* 2011), human herding and mimetic behavior (Girard, 1988; Christakis and Fowler, 2009; Raafat, *et al.,* 2009).

Many of the researchers emphasize the physical attractiveness has a greater influence in societies and culture: In fact, there is a relationship between the level of consumption of plastic surgery and fitness and the market trends to increase their consumption (Kastanakis and Balabanis, 2012).

Objectives

The aim of this thesis consists of analyzing the consumption of two emergent markets: the gym fitness practice and the plastic surgery consumption (segmented according to the procedure's level of invasion into two sub-markets: the low invasive plastic surgery procedures ($LIPS$) and high invasive plastic surgery procedures ($HIPS$)).

Both emergent markets share several commonalities from the demand point of view what explains the interest of their study at the present thesis.

In concrete, our research is focused on modeling the dynamic consumers' behavior of each market from an aggregated point of view that allow us to forecast the rate of Spanish fitness users, $LIPS$ and $HIPS$ consumers for the period of study 2011-2018 and also determine the sensitivity of the consumption of these services by numerical simulations.

For this purpose, we build 3 mathematical models based on quantitative methods:
The first model forecasts the future male fitness consumption in Spain in the next years. Furthermore, we constructed two mathematical models to estimate the future of plastic surgery consumption in Spain in coming years (segmented according to the procedure's level of invasion into two sub-markets: the low invasive plastic surgery procedures ($LIPS$) and high invasive plastic surgery procedures ($HIPS$)). In all models, economic and psychological motivations are taken into account in order to quantify the dynamic behavior of men and women practitioners. Personal and social consequences of these consumptions are studied. Moreover, public health recommendations are suggested.

On the other hand, the specific objectives of this thesis can be detailed as follows:

1. Accurate literature review in order to know the state of the art of these consumptions, and also these sectors.

2. Design of the questionnaire for measuring fitness and plastic surgery consumptions and the variables that incentive their consumption. Sampling at moment "n" and "$n + 1$". Classification of the consumers into subpopulations according to their level of practice / consumptions and dependence.

3. Construction of the mathematical models taking into account: economic, psychological and social contagion parameters.

4. Simulation of the models throughout different economic scenarios measured across the Spanish rate of unemployment; the evolution of the rate of unemployment is based on three prestigious institutions such as the Organization of Economic Cooperation and Development ($OECD$), Spanish Saving Bank Foundation ($FUNCAS$) and International Monetary Fund (IMF).

5. Analysis of the results obtained by the models.

6. Discussion of the results derived from the models and detail of thesis conclusions.

Structure of the thesis

In chapter 1 we analyze previous studies about the two sectors: the fitness practice and the plastic surgery procedures. Also, we explain the factors affecting these markets according to consumers behavior.

In chapter 2 we study the fitness consumption among men. This study allows us to forecast the consumption of fitness practice from 2012 until 2015.

In chapter **??** we build an epidemiological mathematical model focused on the consumption of low-invasive plastic surgery procedures ($LIPS$) in the next years from 2012 until 2018.

Then, in chapter 4 we build and simulate an epidemiological mathematical model for high-invasive plastic surgery procedures ($HIPS$).

The three models presented in this thesis have been built and applied to the case of Spain. Thus, taking into consideration Spanish demographic, sociological, and economic environment.

Finally, in chapter 5 we detail the conclusions derived from the thesis.

Chapter 1

Literature review

1.1 Introduction

The search for a continuous improvement in health, and also in physical appearance is a common pattern that individuals show independently of their origin or nationality.

The tangibility from previous statement can be quantified by the consumption of particular goods and services that are believed to enhance the physical recovery or improvement such as the fitness practice, diet, plastic surgery procedures, cosmetic products, etc.

The reasons that arise under the consumption of this kind of products and services are of different nature: bandwagon (Kastanakis and Balabanis, 2012), mimetic behavior (Girard, 1988), human herding (Raafat *et al.,* 2009), professional success (Sarwer *et al.,* 2003), economic prosperity (Chao and Schor, 1998; Eide and Ronan, 2001).

These facts explain the emergence of two markets that have experienced a rapid growth during last decade worldwide: fitness and plastic surgery procedures. As a result, many companies are set in order to respond to the increasing demand of these goods of consumption.

The study of the consumption of body image products and services have been object of study in the scientific literature from a medical and psychological point of view due to it's massive consumption during last decades (Pope *et al.,* 1997; Sarwer *et al.,* 1998). However, we find a gap in the literature related to the economic reasons that explain the development of the consumption of these products and its link with psychological, social, professional, emotional factors. As consequence, this thesis develops epidemiological mathematical models for forecasting the future consumptions of these goods by numerical simulation, taking into account the above-mentioned variables.

1.2   Fitness consumption

The propagation effect produced by media (advertising campaigns, entertainment, celebrities), society (professional and personal success depends on body image) and the economic situation pushed people to improve their standard of living.

However, individuals are increasingly involved in fitness consumption what can lead to an obsession with their physical appearance and attractiveness. When sportive practices, and in concrete fitness training evolves from a good and healthy habit into an obsession, producing a change in the individuals behaviors.

The first study about obsessive fitness consumption was published by Taylor in 1985. Years later, in 1993, Pope and colleagues (at the laboratory of Mclean Hospital's Biology Psychiatry) observed in their research that a significant number of body builders perceived themselves as small and thin, what made them conclude that there were several commonalities between this phenomenon and the anorexia, but in a reverse way (what mostly affects women), and as consequence they termed this phenomenon as "reverse anorexia".

In 1997, Pope et al., introduced for first time the term " muscle dysmorphia" (MD) to name a form of body dysmorphic disorder (BDD) in which the individuals become pathologically preoccupied with their level of muscularity. They classified it as a subtype of BDD that causes significant distress and functional impairment. Also, it could be associated with depression, social anxiety, self-esteems and social phobia, (Pope *et al.,* 1997; Hitzeroth *et al.,* 2001). However, in 2010, Greenberg et al., and also Phillips et al., concluded about the unclearness whether MD co-occurs with other forms of BDD such as plastic surgery, or anorexia.

In $2000a$, Pope et al., taking into account previous studies in which some athletes had developed a converse syndrome, what means, men perceived themselves as small and frail when in reality they are large and muscular (Olivardia *et al.,* 2000), conducted a study hypothesizing about the possible differences between the ideal men's body in western societies (Europe and USA). Their study showed how there are significant differences between the level of muscularity desired by men (higher than their real one), and also the levels that they thought women preferred. However, the reasons to explain these differences were not conclusive, (Pope *et al.,* 2000a). Several models and theories have been proposed to explain the etiology attributed to MD (Leone *et al.,* 2005). The causes are not yet known, but Leone et al., (2005) emphasizes there are two keys ideas around bigorexia: firstly, bigorexia is assumed to be a form of obsessive-compulsive behavior; secondly, the effect of the media puts some type of pressure on man to conform an ideal body shape, in such way, they become victims of bigorexia. Some writers suggest that body image has two components: distortion and dissatisfaction may relate with onset of MD, (Lantz *et al.,* 2001; McCabe *et al.,* 2005; Martí-González *et al.,* 2012), affecting not only the adult men, but also young boys (Cohane *et al.,* 2001).

Previous studies showed that the individuals with MD develop social problems since they try to spend more time in the gym, what leads them to avoid social events, causing family conflicts, also losing their jobs; exercise becomes the most important priority in their life and this could lead to their social isolation, (Phillips *et al.,* 1995; Pope *et al.,* 1997; Olivardia, 2001).

Many researches have explored the association between negative body effect and unhealthy behaviors. The negative health risk behaviors related to the bigorexia consists of excessive supplements use of anabolic androgenic steroids (AAS), unhealthy dieting and drugs abuse. Several clinical studies trials showed psychological problems such as the change of mood that increases aggressiveness and violence within individuals who used AAS to increase their amount of muscularity (Pope *et al.,* 2009; Walker *et al.,* 2009). These behaviors are the result of the dissatisfaction of men with their body image (French *et al.,* 1995; Greenberg *et al.,* 2010).

Although the exact mechanisms of anabolic steroids produce muscle growth are not clearly delineated, the use of anabolic steroids and supplements has become a part of mainstream fitness users. In $2000a$, Pope et al., said the total number of males from all ages in the USA who used anabolic steroids was more than 2 million, (Pope *et al.,* 2000b). In addition, other studies estimated the athletes who have used anabolic steroids oscillated between more that 1 to 3 million in the USA (Silver, 2001; Brown, 2005).

In $2000b$ Pope et al., claimed that more than 10% of bodybuilders suffered from MD, results validated by Choi *et al.,* (2002) who concluded in their study that men with MD differ sharply from normal weightlifters, most of whom show a small psychopathology.

Rubio and Baile, 2006 analyzed the main characteristics of the fitness users affected by MD such as the delusional obsessive and negative behaviors related with the appearance, thus more excessive exercise, eating disorders, and anabolic steroids consumption (Reas *et al.,* 2006). In fact, bigorexics usually follow a system of nutrition, which is highly restrictive, and they usually consume ergogenic substances (Olivardia *et al.,* 2000, 2001; Pope *et al.,* 2005).

Finally, Nieuwoudt et al., 2012 conclude after reviewing the scientific literature related to MD about the limitations and gaps to classify MD as eating disorder or as dysmorphia disorder. There are few studies relative to the economic and socio-cultural factors that influence individuals to develop consumption the gym.

We found several studies showing a positive relationship between the household incomes and participants of sport. This means that the individual's income is an important factor in deciding to practice sport, (Eide and Ronan, 2001; Farrell and Shields, 2002; Humphreys and Ruseski, 2011). Regardless the results of these studies, the unemployed men have a greater participation at the gym than the ones that are employed. An explanation for this effect is how the culture in the developed societies considers that a man who has an ideal body can achieve a better standard of quality's life (Popkin, 2003), what increases

individual's consumption and expenditure on health goods and services.

Other driver related to the development of MD is the intention of men to increase their attractiveness to other men or women; what according to previous studies (Brown and Graham, 2008; Chaney, 2008), may lead homosexuals to higher rates of gym practice. Furthermore, according to Pompper (2010), men are afraid of being feminine, and as consequence the concept of masculinity influences the shape of the men.

The socio-cultural factors that could influence the development of MD can be classified into three environmental sources: messages from the family, friends and media (e.g., fashion models, athletes and entertainment) (Olivardia *et al.*, 2000; Ricciardelli and McCabe, 2003; Keery *et al.,* 2004). The cultural values and preferences may influence and shape BDD symptoms (Phillips, 2005). Also, peer pressure among teenage boys, until the extreme of the bullying (Wolke and Sapouna, 2008), as parental comments, media and society influence boys' behavior, who feels the need of controlling his body weight and shape from a young age (Smolak *et al.,* 1999).

In 2009, Peyró and Oñate concluded in their study MD causes the appearance of anxiety, depression and body dissatisfaction among men. However, since MD or bigorexia has not yet recognized as a disease, there are not standardized medical procedures developed for its treatment. So far, there is just the cognitive-behavior therapy (CBT), which is a clinical treatment that reduces the symptoms of BDD. And also in 2010, Murray et al., classified MD as an independent disease entity, a condition derived from the so-called body image disturbance (Murray *et al.,* 2010).

1.3   Plastic surgery consumption

Plastic surgery embraces all medical treatments focused on restoring the shape of body image and its function. Swami et al., 2009c defined the plastic surgery as the maintenance of the physical appearance through the surgical or medical techniques. Also, British Association of Plastic, Reconstructive and Aesthetic Surgeons ($BAPRAS$) defined it as various surgical skills and techniques that attempt to restore humans appearance and functions after the illness (BAPRAS, 2014).

As early, the ancient Egyptians used it and named the surgical treatise but the first reconstructive techniques were carried out by Hindu in 600 $B.C$ (Donohoe, 2006; ASPS, 2014).

Plastic surgery also known as cosmetic surgery it includes many types of surgical treatments: reconstructive surgery, hand surgery, microsurgery

One branch of plastic surgery is the cosmetic surgery which can be divided into two main types of procedures: low-invasive and high-invasive, according to the kind of the surgical treatment and the cost of the procedures. Its consumption shows an increasing trend, enlarging the international market (private clinics) due to the importance conceived by women to body image \ care.

The main customer of the cosmetic surgery market are women. In fact, according to recent data (Sondea, 2013) 70% of Spanish women would undergo an esthetic treatment in order to improve their physical appearance while a 35% has already undergone treatment.

Behind the interest expressed by women for improving their physical image can be found out different reasons such as dissatisfaction with their bodies but also aging anxiety, search of sexual attractiveness. Then, plastic surgery procedures emerge as the tool to diminish unpleasant feelings (sadness, emptiness and low self-esteem). When the body image becomes an obsession for the person who undergoes cosmetic treatments compulsively, then this behavior is associated to body dysmorphic disorder such as bigorexia, anorexia nervosa, bulimia and obesity.

The first research in this line was carried out by Phillips et al., in 1993 who studied how over 95% of patients diagnosed with BDD avoided social activities and in general the patients responded poorly to surgical treatments. Later on, Veale et al., found the 26% of individuals diagnosed with BDD had performed cosmetic surgery at least once (Veale *et al.,* 1996). In 1998a Sarwer, et al., concluded that plastic surgery performances produce a physical appearance change which translates into a higher level of psychological well-being and self-confidence.

Several studies show 7% to 7.7% of females with plastic surgery compulsive performance have symptoms of BDD (Sarwer *et al.,* 1998b; Sarwer, 2002; Lai *et al.,* 2010) such as mental disorder, physical appearance dissatisfaction, self-esteem and anxiety, those factors make women undergo surgery.

In 1999 Grossbart and Sarwer, suggested there are two categories of motivation for undergoing plastic surgery: internal and external. Internal motivation emerges when the person has a low level of self-esteem while external is produced by the media, the search of improvement of the image. In 2006 Sarwer and his colleagues explored further the relationships among physical appearance, body image and psychosocial functioning (Sarwer *et al. ,*1998b; Sarwer *et al.,* 2006).

Women are influenced by socio-cultural patterns and compare their physical appearance with other people like celebrities pressing themselves about their body image performing such as augmentation or reduction of their breasts or also performing anti-aging surgeries, gym practices. Indeed, eating disorders are usually correlated with the consumption of aesthetic surgical practices (Mclntosh *et al.*, 1994; Henderson-King and Henderson-King, 2005; Odunze, 2006; Honigman and Castle, 2006; Andreoni and Petrie, 2008; Brooks,

2010; Maltby and Day, 2011; Smirnova, 2012; Garnham, 2013).

In fact, most people performing cosmetic surgery procedures seek for a good image only to enhance better psychosocial status and social recognition. (Kvalem et al., 2006; Delinsky, 2005; Sarwer et al., 2005a; Frey et al., 2007; Swami et al, 2008; Swami et al, 2009a; Markey and Markey, 2010).

After surgery practice a proportion of women could be dissatisfied again with their body image by comparison with other females from their neighborhood or from the media. This phenomenon is embracing the propagation or contagion effect, human herding and mimetic behavior (Girard, 1988, Sarwer *et al.,* 1998b; Grossbart and Sarwer, 1999; Sarwer *et al.,* 2006; Christakis and Fowler, 2009; Raafat, *et al.,* 2009; Slevec and Tiggemann, 2010).

Previous studies showed there is a relationship between the increasing popularity of plastic surgery and consumers caused by the higher disposable incomes, also due to the lower cost of the procedures (Duncan, *et al.,* 2004; Liu and Miller, 2008). On the other hand, as a result of the economic crisis the demand has decreased, reducing the market prices due to the level of competition.

Thus, plastic surgery has become a normal good of consumption and it is affected by the fluctuations of the economy as any other economic sector. It is important to distinguish between invasive and expensive procedures that follow the pattern of luxury goods (Chao and Schor, 1998; Alsarraf *et al.,* 2002; Wimalawansa *et al.,* 2009; Devgan and Grant, 2010; Eriksen and Goering, 2011; Hoyer and Stokburger-Sauer, 2012; Stokburger-Sauer and Teichmann, 2013; Luo, 2013) and are mainly affordable by high-income population while surface treatments like Botox$^{®}$ fillers are affordable to most of population (Castle *et al.,* 2004; Singh *et al.*, 2006; TAC, 2012; PSR, 2010; BAAPS, 2013).

Moreover explicitly, during expansive economic periods expensive surgical procedures become more affordable to general population due to an improvement of credit liquidity, while during economic recessions those expensive surgery treatments are almost exclusive for rich people (Kurkjian, *et al.,* 2011).

In addition, most of research emphasize the physical attractiveness has a greater influence in societies and culture that there is a relationship between BDD and trends to increase consumer behavior of fitness center and plastic surgery (Pope *et al,* 1997; Sarwer and Crerand, 2008; Ghadakzadeh *et al.,* 2011; Hoyer *et al.,* 2012; Nieuwoudt *et al.,* 2012).

Finally, literature shows the consumption of plastic surgery is related to psychological drivers (Chandler *et al.,* 2009; Rees *et al.,* 2012). However, plastic surgery not only produces body rejuvenation or improvement but also measures the well-being status (Sarwer and Whitaker, 2011). Hence, its consumption is directly linked to the economic situation, allowing individuals to spend more money to look better during economic booms (Pan, 2011; Marsidi, *et al.,* 2014).

Chapter 2

Modeling the behavior of fitness users in Spain: An emergent business with social and public health consequences

Summary

Under forty years old males increase their gym practice with the aim of improving their body image as a way of reinforcing their personal self-esteem and their sexual appeal. Those cases when self-image becomes an obsession may emerge a body dysmorphic disorder named Muscle Dysmorphia (MD) emerges in those cases when self-image becomes an obsession. The combination of psychological, environmental and biological drivers determines the appearance and development of this disorder. In this chapter we develop a discrete population mathematical model to forecast the rate of prevalence of males who are non-competitive bodybuilders at risk of suffering from muscle dysmorphia (MD) in Spain in the next years. Economic, emotional and psychological motivations are taken into account in order to quantify the dynamic behavior of non-competitive bodybuilders. Also, by first time we introduce in the study of the MD the sociological influences such as the human herding and social propagation. Our results predict an increase from 1% in 2011 to around 11% in 2015 of the Spanish non-competitive bodybuilders suffering from MD. Also, our model can be applied to any other western country where data are available as well as to another period of study in which the hypotheses remain applicable.

2.1   Introduction

The physical fitness prevalence of men has extended in western societies. Both men and women are preoccupied about their body image appearance. As consequence the sector of fitness centers has developed dramatically worldwide since the decade of the $90's$.

In the international context, it is remarkable the case of United States (USA) where more than 45.3 million people attended the gym in 2010. According to the International Health, Racquet & Sports-Club Association (IHRSA, 2010), there were around 29 750 health clubs in 2010 in USA, and the total revenues of this sector were around 19.5 million dollars in 2009 (IHRSA, 2010). However, despite the economic downturn in the USA the annual growth of the fitness industry has been around 0.9%, since 2008, reaching a total turnover of 20.5 million dollars in 2012, (IBISWorld, 2012).

In the European framework, it is relevant the case of Germany where there were more than 90 000 sports clubs in 2011, that means that body building entertainment consumption is in expansion with an annual budget per capita over 600 Euros in sports goods. Also, the number of health club membership reached more than 4.97 million people in 2010 (Pan, 2011).

For the particular case of Spain, the fitness sector turnover (just considering private gyms) reached a total volume of 1 065 million Euros in 2008, decreasing as consequence of the economic crisis to 920 million Euros in 2010, and continue to decrease in 2011 to 865 million, then to 800 million Euros in 2012 (a decrease of 24.88% from 2008 to 2012) (see figure 2.1). However, even when the revenues have decreased because of the economic crisis, the number of fitness centers remains stable (see figure 2.2), with a total number of 4 450 private gym centers in Spain in 2010, (DBK, 2013). It is remarkable the high level of concentration that characterizes the Spanish fitness sector, 10 gym centers (franchises) concentrate the 33% of the fitness market.

Figure 2.1: Total annual turnover of private gyms in Spain (Million of Euros).
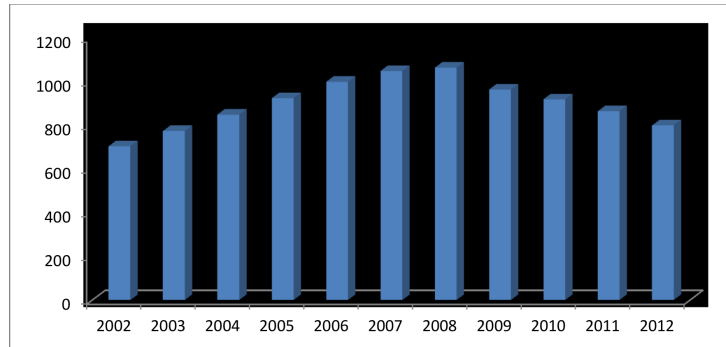
Source: Own performance from data available by DBK, Análisis de sectores, (2013).

Figure 2.2: Total number of private gyms in Spain (Thousands).
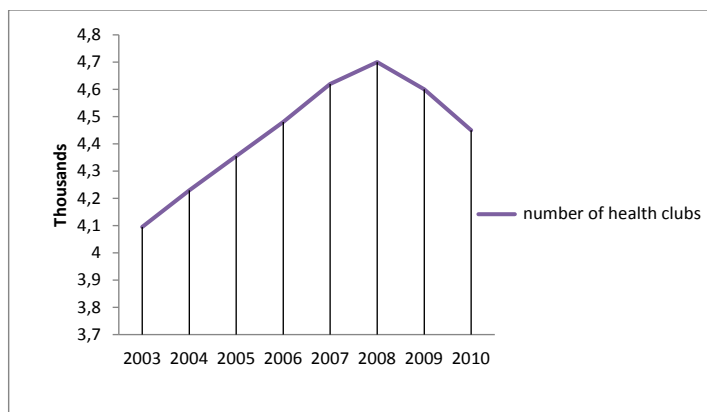
Source: Análisis de sectores, (DBK, 2010).

Even when the private sector shows a decrease of the total turnover due to the crisis, the public gyms run by private companies produced an annual increase of their turnover of 10% from 2006 until 2009 (Figure 2.3). Related to this it is the fact that the Spanish population who practice exercise has evolved from 27% in 2005 to 35% in 2010, showing a significant increase of their sportive practices, according to the survey of Sportive Habits in Spain developed by the Spanish Center for Sociological Research, (Ferrando and Goig, 2011).

Figure 2.3: Total annual turnover of public gyms run by private companies in Spain (Million of Euros).
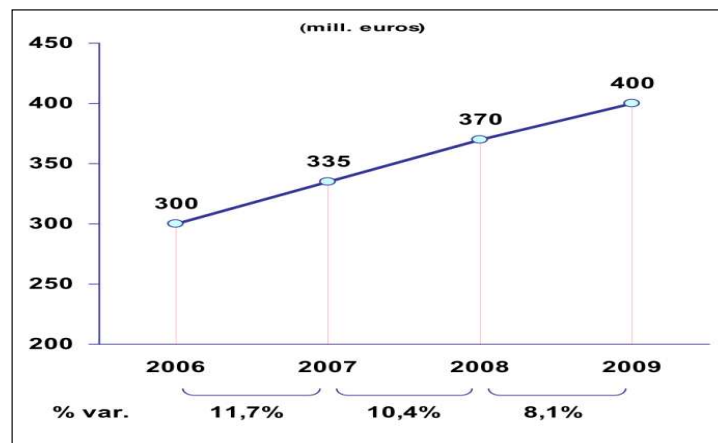
Source: Análisis de sectores, (DBK, 2010).

Also, in this context it is relevant the role of the media and fashion industry encouraging people to take care of their image, influencing society's behavior. Examples of this are TV commercials showing young people with perfect bodies, movies, fitness magazines, marketing campaigns and websites promoting slimming products and beauty treatments (Pope *et al.,* 2000b). A significant product of this trend is the fact that in 2009 the 74% of the Spanish public gyms had a fitness room for body building (Ferrando and Goig, 2011).

As a result of the cult for the body image, a new pathology has emerged in those cases when self-image becomes an obsession. We are talking about bigorexia or muscle dysmorphia (Blashfield *et al.,* 1990; Mosley, 2009; Nieuwoudt *et al.,* 2012), a disorder in which the person becomes obsessed with the idea that he or she is not muscular enough. This disorder affects mainly to men (Phillips, 2009). The individuals who suffer from it think their body shape and size is skinny or too small. They develop obsessive and negative behaviors related with their appearance.

13

The prevalence of muscle dysmorphia also named "reverse anorexia" is unknown, previous studies in an effort to quantify its prevalence conclude that affects to the 10% of bodybuilders (Pope *et al.,* 1997). However, the international medical community does not yet recognize it as a disease. Between the common patterns of the population affected by bigorexia are the excessive practices of exercise, appearance of distress if they miss a workout session, special diets and use of anabolic steroids (Pope *et al.,* 1997; Segura-García *et al.,*2010).

The Spanish General Council of Pharmacists estimated around $700\,000$ people consumed doping substances in Spain in 2011 in order to increase their muscles mass, (Salinas, 2011). Even when there are not conclusive results, the estimation of Spanish people with dysmorphic disorder was around $20\,000$ in 2011 (Salinas, 2011).

In this framework, this part of the thesis tries to develop a discrete population mathematical model to forecast the number of consumers of fitness users in Spain in the next five years. For this purpose, economic and psychological motivations are taken into account in order to quantify the dynamic behavior of men gym users. Also, personal and social consequences of this consumption are studied and public health recommendations are suggested.

The chapter is structured as follows: In section 2.1 we showed an introduction; In section 2.2 the methods of the study are explained; section 2.3 shows the results and economic simulations of the study and finally in section 2.4 the conclusions are expressed.

2.2 Methods

The population of the study is composed by the Spanish men who attend the gym aged between the interval $[18, 40]$.

In order to analyze the consumption behavior of the gym users and in particular to analyze the MD pathology of the non-competitive bodybuilders, the questionnaire Test Breve de Vigorexia (TBV) (Baile, 2005) was adapted to our study. The version applied in this study consisted of 10 questions. Also, we added some socio-demographic questions in order to know the profile of our sample. The questionnaire measures both, the level of non-competitive bodybuilding activity and also the individuals' psychological dependence to the this practice (see appendix $A.A$ and $B.A$).

Then, we classified the individuals into three categories according to their score (obtained from the sum of participants' answers in the questionnaire as follows:

- N: Defined as incidental-consumers of gym were those men whose score was equal or lower than 2 points in the questionnaire, also their number of non-competitive bodybuilding sessions is 1 or 2 per week.

- S: Frequent-consumers of gym were those men whose score obtained in the questionnaire was equal to 3 or 4 points, and attend the gym at least three times per week.

- A: Non-competitive bodybuilders at risk to develop MD whose score in the questionnaire was higher than 5 points, and also attend the gym more than 3 times per week.

2.2.1 Participants

We passed the questionnaire twice, once in 2011 and second time 2012 in both locations, the public gym of Polytechnic University of Valencia UPV and also at private multi-located gym. The stratified sampling method based on the age of the Spanish population was applied. Participants were asked to complete the TBV composed by 10 questions.

Table 2.1 shows data collected from the two samplings $(T1, T2)$, and also the classification of the Spanish gym users by subpopulations after adjusting statistically using data from the Spanish Statistical Institute (INE) and Ferrando and Goig (2011).

	2011		2012	
		Spanish gym population		Spanish gym population
	Sample		Sample	
N	187	537 092	167	486 744
S	12	34 466	27	78 695
A	2	5 744	4	11 659
Total	201	577 302	198	577 098

Table 2.1: Data collection and Spanish population distribution for 2011 and 2012.

As Table 2.1 shows the proportion of frequent non-competitive bodybuilders (S) and non-competitive bodybuilders at risk of suffering $MD(A)$ increased considerably in Spain from 2011 to 2012. Following in section 2.2.2, we build a mathematical model to explain the development of these consumption services according to economic, social, and contagion drivers.

2.2.2 Mathematical model

The purpose of this section is to develop a discrete mathematical model, which allows us to determine the behavior of the gym consumers in the future years $[2012 - 2015]$. As it was commented in the previous section, the population object of study was divided into three categories according to their score obtained in the TBV test (Baile, 2005).

Our attention is focused on forecasting the number of: incidental-consumers of gym (N), frequent gym user (S) and the those men at risk of developing MD (A).

The non-competitive bodybuilder's behavior is dynamic, that means, this can vary over time, and embraces interactions and changes of individuals between subpopulations. For this, the mathematical model used to describe this dynamic is a system of difference equations whose unknowns are:

- $N(n)$ = Number of males that are incidental-consumers of gym aged $[18, 40]$ at year n.

- $S(n)$ = Number of males that are frequent-consumers of gym aged $[18, 40]$ at year n.

- $A(n)$ = Number of males that are non-competitive bodybuilders to the gym aged $[18, 40]$ at year n.

The total population (P) in the time n is given by:

$$P(n) = N(n) + S(n) + A(n). \tag{2.1}$$

The dynamic behavior of the gym consumers is based on their transit between subpopulations explained by coefficients that need to be modeled according to economic, sociodemographic and contagion hypothesis.

The period of study begins in 2011, when the first sample of the study was obtained. Then, the variation between subpopulations N, S and A was estimated for the interval $[n, n + 1]$. Following, the hypothesis of the model are presented:

Hypothesis of the model:

1. The individuals come into the model only as incidental-consumers (N) under two hypotheses:

    a Male non-competitive bodybuilder older than 17 years old. It is assumed that the increase of incidental-consumer (N) and frequent-consumer (S) at year n is equal to the Spanish birth rate at that year, $b_i(n-18)$, while it is 0 for MD non-competitive bodybuilders (A).

    b Also, as a result of an economic improvement, measured throughout the unemployment rate $u_{(n)}$, in case it occurs, population invests more money on sportive practices increasing the N subpopulation, $\alpha_u(n)$, (Eide and Ronan, 2001; Farrell and Shields, 2002; Humphreys and Ruseski, 2011).

2. The gym consumers leave the model at year n, due to possible scenarios:

    a The gym consumer becomes older than 40 years old or he passes away at year n, d_i.

    b As a result of the economic crisis, a proportion of the incidental-consumer (N) emigrates abroad, giving up on their gym practices, α_f.

    c Due to the economic deterioration, incidental-consumer decreases their sportive practices, since the gym may become a luxury good. However, frequent-consumer (S) and MD non-competitive bodybuilders (A) do not decrease their gym attendance, $\alpha_u(n)$.

3. The individuals can only transit from one category or subpopulation to another, (Christakis and Fowler, 2009; Raafat, *et al.,* 2009). Thus, the incidental-consumers (N) can transit to frequent-consumer (S) and the frequent-consumer (S) to MD non-competitive bodybuilders (A), γ_1 and γ_2. Also, it is assumed a possible recovery transit from a frequent-consumer (S) to an incidental-consumer (N), $\alpha_2(n)$.

The individuals transit's are due to their own characteristics but also due to their environment's conditions (economic and personal drivers) that define their behavior (Girard, 1988; Christakis and Fowler, 2009; Raafat, *et al.,* 2009). Hence, the transits between subpopulations are due to:

a The influence of personal experiences during childhood (bullying) (Wolke and Sapouna, 2008; Boyda and Shevlin, 2011), also looking for improving their sex-appeal (Brown and Graham, 2008; Chaney, 2008; Pompper, 2010) or rebuilding their personal life after a divorce or being deprived of a person (Duato and Jódar, 2013), defined by α_e.

b The combination of opposite drivers such as an emotional impact and the economic recovery, $\alpha_t(n)$.

c The influence of personal relationships, especially with MD non-competitive bodybuilders (A), is a determinant of the people's habits, behaviors' as their diet, the special products they consume, γ_1 and γ_2 (Christakis and Fowler, 2009; Raafat *et al.,* 2009).

d The influence of an economic improvement, if it happens, (decrease of unemployment rate) combined with the rebuilt of the personal life can produce a backward transit from a frequent-consumer (S) to an incidental-consumer one (N), $\alpha_2(n)$ (Popkin, 2003).

The dynamics of the model can be described by the following equations:

$$
\left.
\begin{aligned}
N(n+1) - N(n) &= b_1(n-18)N(n) - d_1 N(n) + \alpha_2(n)S(n) \\
&\quad - \alpha_e N(n) - \gamma_1 N(n) - \alpha_f N(n) + \alpha_u(n)N(n), \\[4pt]
S(n+1) - S(n) &= b_2(n-18)S(n) - d_2 S(n) + \alpha_e N(n) \\
&\quad - \alpha_2(n)S(n) + \gamma_1 N(n) - \alpha_t(n)S(n) - \gamma_2 S(n), \\[4pt]
A(n+1) - A(n) &= b_3(n-18)A(n) - d_3 A(n) + \alpha_t(n)S(n) + \gamma_2 S(n).
\end{aligned}
\right\}
\quad (2.2)
$$

This can also be written in the more compact $X(n+1) = A(n)X(n)$, where $X(n) = (N(n), S(n), A(n))^T$ is the population vector and A(n) is the matrix of coefficient transits given by

$$
A(n) = \begin{bmatrix}
\ell_1(n) & \alpha_2(n) & 0 \\
\alpha_e + \gamma_1 & \ell_2(n) & 0 \\
0 & \alpha_t(n) + \gamma_2 & \ell_3(n)
\end{bmatrix}, \quad (2.3)
$$

where $\ell_1(n) = 1 + b_1(n-18) + \alpha_u(n) - (d_1 + \alpha_e + \gamma_1 + \alpha_f)$,
$\ell_2(n) = 1 + b_2(n-18) - (d_2 + \alpha_2(n) + \alpha_t(n) + \gamma_2)$ and $\ell_3(n) = 1 + b_3(n-18) - d_3$.

Also, as follows it is the expressed the dynamics of the model (Figure 2.4)

Figure 2.4: Dynamics of the population.
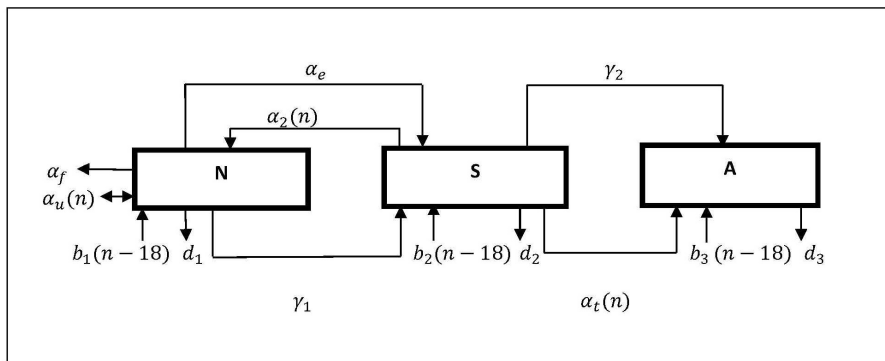
Source: Own performance.

Computation and estimation of the parameters

The values of all parameters were estimated from different sources of information and hypothesis with the exception of the transit γ_1 that was adjusted by the model.

Following, the parameters of the model are estimated:

- $b_i(n - 18)$: Birth rate of the population in 1993 by categories ($i = 1, 2, 3$) in 2011, (INE,2009). We assume the birth rate is distributed between N and S subpopulations; the 80% of the incoming non-competitive bodybuilders in the age interval $[18, 40]$ belong to N subpopulation, while the remaining 20% comes into the model as S subpopulation (Arango, 2010). Hence, the transit coefficients are measured as follows: $b_1(n - 18) = 0.8 \times (10.66/1000) = 0.008528$; $b_2(n - 18) = 0.2 \times (10.66/1000) = 0.002132$ and $b_3(n - 18) = 0$.

- d_i: Spanish mortality rate in 2011 by categories of non-competitive bodybuilders ($i = 1, 2, 3$). We assume this rate remains constant for the period 2011-2015, where $d_i = (8.8/1000)/3 = 0.00293$.

- $u(n)$: Is the unemployment rate at the year n. For the year 2011 the unemployment rate proceeds from the INE. For the next years 2012 and 2013, the economic forecast is taken from the Organisation for Economic Cooperation and Development ($OECD$), and the Spanish Saving Bank Foundation ($FUNCAS$). For 2014 and 2015 we assumed four possible scenarios from the $OECD$ and $FUNCAS$ forecast: $OECD$ optimistic and pessimistic ($OECD+, OECD-$) and also the $FUNCAS$ optimistic and pessimistic scenarios ($FUNCAS+, FUNCAS-$). Additionally, we considered two more scenarios, one optimistic and other pessimistic based on our assumption; this way we cover all possible developments of the unemployment rate in the period $2011 - 2015$.

- α_f: It is defined as the emigration rate caused by unemployment in Spain. A total of $150\,000$ people left Spain in 2011 looking for a job abroad (Sánchez, 2013), of this number, a 5% were non-competitive bodybuilder (Ferrando and Goig, 2011); thus,
$$\alpha_f = (0.05 \times 150\,000)/537\,064 = 0.014$$

  We assume the population that emigrates was incidental-consumer (N); This rate remains constant for the period $2011 - 2015$, (Arango, 2010).

- $\alpha_u(n)$: Economic influence over N subpopulation. From the observed data in previous years from INE and Ferrando and Goig (2011), it is assumed that for each 1% decrease of the unemployment rate the N category increases 0.4% at year n; also for each 1% increase of unemployment rate, the N category decreases 0.2% at year n. Then,

$$\alpha_u(n) = \begin{cases} -0.004 \times (u(n+1) - u(n)) & \text{if } u(n+1) < u(n), \\ -0.002 \times (u(n+1) - u(n)) & \text{if } u(n+1) \geq u(n). \end{cases} \tag{2.4}$$

- $\alpha_2(n)$: Rate of possible recovery of the S subpopulation estimated as the sum of two non-negative components, an economic one due to unemployment rate recovery (α_{21}) and/or emotional personal life recovery (α_{22}).

1. α_{21}: If the economy improves, the non-competitive bodybuilder reduces his physical activity due to a reduction of his spare time. Thus, the 80% of the jobs produced by the economic recovery (estimated through the annual unemployment rate (INE)) are absorbed by the population aged in the interval $[18, 40]$ from whom a 5% are non-competitive bodybuilders (Ferrando and Goig, 2011).

   Then,

$$\alpha_{21}(n) = 0.05 \times (u(n+1) - u(n))^- \times 0.8 \tag{2.5}$$

   Where,

$$(u(n+1) - u(n))^- = \begin{cases} u(n) - u(n+1), \ u(n+1) < u(n) & \text{if the economy recovers,} \\ 0 & \text{if } u(n+1) \geq u(n). \end{cases} \tag{2.6}$$

2. The second component α_{22} that determines the transit from frequent-consumer to incidental-consumer improving their self-esteem level through their personal life rebuilt by coupling. We estimate α_{22} as the proportion of non-competitive bodybuilders over the total Spanish population aged $[18, 40]$ (5%) (Ferrando and Goig, 2011), that rebuild their life, what is estimated in terms of the marriage rate in Spain in 2008 (INE).

   Hence,
$$\alpha_{22} = 0.05 \times 0.7796 = 0.0389.$$

   We assume this rate remains constant for the period of study, (Ferrando and Goig, 2011).

- α_e: Rate of the emotional status. The emotions and past experiences may define the non-competitive bodybuilder attitude mainly motivated by a low level of self-esteem. The emotional rate is estimated as the combination of the weighted average

of two addends corresponding to the proportion of non-competitive bodybuilders practices according to two significant age intervals: $[18, 25]$ corresponding to those bodybuilders living at their parents' and $[26, 40]$ defined by non-competitive bodybuilders assumed economically self-sufficient.

1. α_{e1}: Estimated as the proportion 9.06% (INE, 2011) of Spanish people aged in the interval $[18, 25]$, (5%) of them are non-competitive bodybuilders, and have lower level of self-esteem as consequence of their past experiences such as a childhood trauma (4%) (Wolke and Sapouna, 2008), or they search for improving their physical attractiveness (8%), (Hönekopp *et al.,* 2007; Brown and Graham, 2008; Pompper, 2010; Varangis, *et al.,* 2012) but also other causes 1% (emotional drawbacks). In all cases the individuals are pushed to the fitness practice.
   Then, α_{e1} is weighted as $\frac{1}{3}$ of $\alpha_e(\frac{9.06\%}{25.63} = \frac{1}{3} = 0.33)$, where 9.06% is the Spanish rate of men aged $[18, 25]$ years old in 2011(INE), 25.63% Spanish rate of men aged $[26, 40]$ years old(INE).

$$\alpha_{e1} = 0.33 \times (0.0906 \times 0.05 \times 0.13) = 0.0001943$$

2. α_{e2}: Is the proportion of Spanish people aged in the interval $[26, 40]$, that are non-competitive bodybuilders (5%), and experience any of the following status: divorce (35%), childhood trauma (4%) (Wolke and Sapouna, 2008), or they look for improving their physical attractiveness (8%), (Hönekopp, *et al.,* 2007; Brown and Graham, 2008; Pompper, 2010; Varangis, *et al.,* 2012). Also other causes 1% (emotional drawbacks).

$$\alpha_{e2} = 0.66 \times [(0.2563 \times 0.05) \times (0.13 + 0.35)] = 0.004059792$$

Then,

$$\alpha_e = \alpha_{e1} + \alpha_{e2} = 0.0001943 + 0.004059792 = 0.004254092$$

- $\alpha_t(n)$: Is the rate of transit from frequent-consumer (S) to non-competitive bodybuilder suffering from MD (A) $S \rightarrow A$ as consequence of the combination of opposite effects, the emotional impact rate (α_e) and an economic recovery (α_{21}). It is defined as follows:

$$\alpha_t(n) = \alpha_e - \alpha_{21} = 0.004254092 - (0.05 \times (u(n+1) - u(n))^- \times 0.8)$$

- γ_1: Is the propagation effect derived from the interaction and human herding between a non-competitive bodybuilder with MD (A) and an incidental-consumer (N), the incidental-consumer (N) transits to frequent-consumer (S). This value was adjusted from the model, using the data collected by the two samples previously quoted in section 2.2.1 $\gamma_1 = 0.08415$, (Christakis and Fowler, 2009; Raafat, *et al.,* 2009).

- γ_2: Is the propagation effect produced by the interaction and human herding between A and S, then frequent-consumer (S) transit to non-competitive bodybuilder with MD (A), $S \rightarrow A$; γ_2, is assumed constant for all years. We assume that this coefficient is twice the value of γ_1, due to the fact that (S) frequent gym consumers have a stronger tendency to mimic regular gym consumers because they look at the *"mirror effect"* produced by MD bodybuilders, (Christakis and Fowler, 2009; Raafat, *et al.,* 2009). After matching data the found value was $\gamma_2 = 2 \times \gamma_1$.

It is important to remark that we will study in section 2.3 the robustness of the model versus a change of the propagation parameter γ_2.

2.3 Results and Simulations

2.3.1 Results of the model

The mathematical model allows us to forecast the subpopulations $N(n)$, $S(n)$ and $A(n)$ at any year n by computing the solution of the difference system. As we have noticed in the model building, the economy has a prevalent influence over the subpopulations' transits mainly measured by the unemployment level.

In the previous subsection 2.2.2, we defined the expression of each coefficient of the system apart from the economic dynamics measured throughout the Spanish unemployment rate, as it was previously mentioned. Since in the next years the real economic situation is unknown, we assume several economic scenarios based on the opinions of prestigious institutions such as $OECD$ and $FUNCAS$. Due to the high volatility of the Spanish economy, these institutions only provide forecasts until the end of 2013. As our study period is until the end of 2015, we assumed for 2014 and 2015 reasonable economic scenarios following the forecast of $FUNCAS$ and $OECD$. Furthermore, we built a double economic scenario, named $OECD+$, $FUNCAS+$ and $OECD-$, $FUNCAS-$. Finally, we introduced two other scenarios, one optimistic and one pessimistic for the total period of study; thus, any possible real economic future situation will be enclosed in the range of variation of our scenarios.

Simulation of economic scenarios

As a result we simulate six possible scenarios according to the levels of unemployment,(see at table 2.2).

	OECD +	OECD -	FUNCAS +	FUNCAS -	Optimistic	Pessimistic
2011	0.23	0.23	0.23	0.23	0.23	0.23
2012	0.245	0.245	0.245	0.245	0.23	0.26
2013	0.253	0.253	0.263	0.263	0.21	0.27
2014	0.219	0.225	0.25	0.26	0.19	0.28
2015	0.215	0.223	0.231	0.248	0.18	0.29

Table 2.2: Economic forecast of the Spanish unemployment rate in percentages.
Source: Own performance from data available by INE, $OECD$ and $FUNCAS$.

Once the economic scenarios are built, the following (table 2.3) collects the results performed by the computation of the system in volume of users and also in percentages (tables 2.4, 2.5, 2.6, 2.7, 2.8, 2.9).

		OECD +	FUNCAS +	OECD -	FUNCAS -	Optimistic	Pessimistic
	N	537 092	537 092	537 092	537 092	537 092	537 092
2011	S	34 466	34 466	34 466	34 466	34 466	34 466
	A	5 744	5 744	5 744	5 744	5 744	5 744
	N	484 850	484 850	484 850	484 850	486 460	483 239
2012	S	80 573	80 573	80 573	80 573	80 573	80 573
	A	11 674	11 674	11 674	11 674	11 674	11 674
	N	440 297	439 327	440 297	439 327	444 474	438 651
2013	S	120 228	120 228	120 228	120 228	120 370	120 086
	A	25 543	25 543	25 543	25 543	25 543	25 543
	N	408 201	403 723	407 173	402 013	409 615	399 178
2014	S	154 531	154 373	154 376	154 339	154 921	154 037
	A	46 377	46 276	46 348	46 227	46 334	46 141
	N	375 352	373 624	374 102	370 983	377 592	365 019
2015	S	184 492	184 038	184 241	183 810	185 030	183 134
	A	72 930	72 894	72 861	72 797	72 992	72 523

Table 2.3: Results of the model for N, S and A subpopulations in volume of users according to the assumed scenarios.

	OECD+		
	N	S	A
2011	93.03%	5.97%	1.00%
2012	84.02%	13.96%	2.02%
2013	75.13%	20.51%	4.36%
2014	67.02%	25.37%	7.61%
2015	59.32%	29.16%	11.53%

Table 2.4: Results of the model according to the $OECD$ optimistic economic scenario ($OECD+$).

	OECD −		
	N	S	A
2011	93.03%	5.97%	1.00%
2012	84.02%	13.96%	2.02%
2013	75.13%	20.51%	4.36%
2014	66.98%	25.40%	7.62%
2015	59.27%	29.19%	11.54%

Table 2.5: Results of the model according to the $OECD$ pessimistic economic scenario ($OECD-$).

	FUNCAS +		
	N	S	A
2011	93.03%	5.97%	1.00%
2012	84.02%	13.96%	2.02%
2013	75.09%	20.55%	4.37%
2014	66.80%	25.54%	7.66%
2015	59.25%	29.19%	11.56%

Table 2.6: Results of the model according to the $FUNCAS$ optimistic economic scenario ($FUNCAS+$).

	FUNCAS −		
	N	S	A
2011	93.03%	5.97%	1.00%
2012	84.02%	13.96%	2.02%
2013	75.09%	20.55%	4.37%
2014	66.72%	25.61%	7.67%
2015	59.11%	29.29%	11.60%

Table 2.7: Results of the model according to the $FUNCAS$ pessimistic economic scenario ($FUNCAS-$).

	Optimistic		
	N	S	A
2011	93.03%	5.97%	1.00%
2012	84.05%	13.92%	2.02%
2013	75.28%	20.38%	4.32%
2014	67.05%	25.36%	7.58%
2015	59.40%	29.11%	11.48%

Table 2.8: Results of the model according to optimistic economic scenario.

	Pessimistic		
	N	S	A
2011	93.03%	5.97%	1.00%
2012	83.97%	14.00%	2.02%
2013	75.07%	20.55%	4.37%
2014	66.60%	25.70%	7.69%
2015	58.80%	29.50%	11.68%

Table 2.9: Results of the model according to pessimistic economic scenario.

As tables (2.4, 2.5, 2.6, 2.7, 2.8, 2.9) show, the percentages of S and A increase over time independently of the economic scenario, with scarce differences between them, what confirms the robustness of our model.

The S subpopulation evolves from 5.97% in 2011 to the interval $[29.11\%, 29.50\%]$ in 2015 depending on the economic scenario; while the rate of prevalence of non-competitive bodybuilders at risk of suffering MD in Spain increases (A) from 1% in 2011 to the interval $[11.48\%, 11.68\%]$ in 2015 depending on the economic scenario.

We can show that in the figures as follows: 2.5, 2.6 and 2.7.

Figure 2.5: Forecast of incidental-consumer (N) subpopulation by economic scenarios [2011-2015].
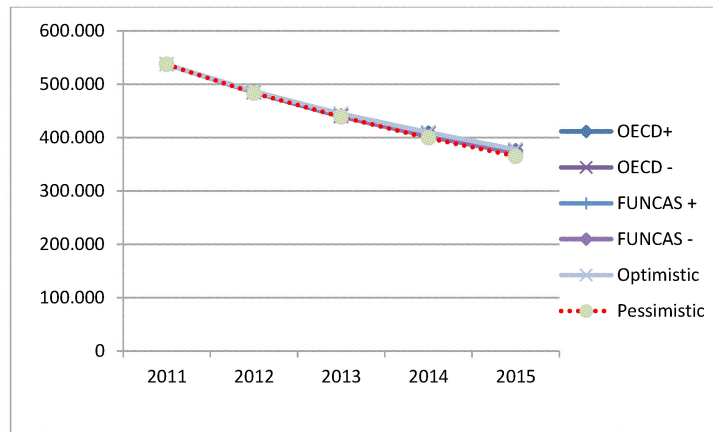
Source: Own performance.

Figure 2.6: Forecast of frequent-consumer (S) subpopulation by economic scenarios [2011-2015].
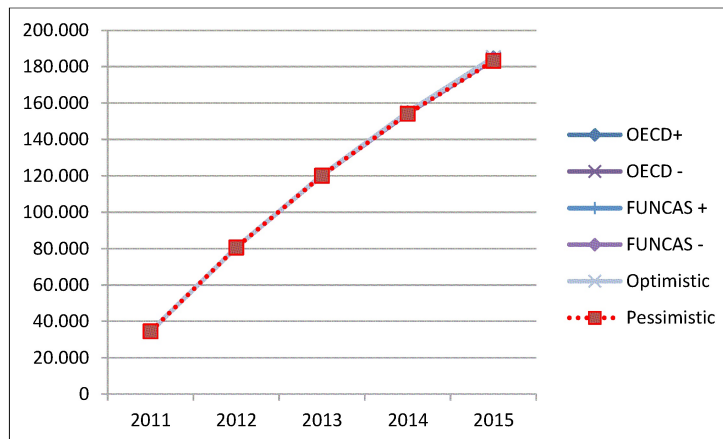
Source: Own performance.

Figure 2.7: Forecast of non-competitive bodybuilder with MD (A) subpopulation by economic scenarios [2011-2015].
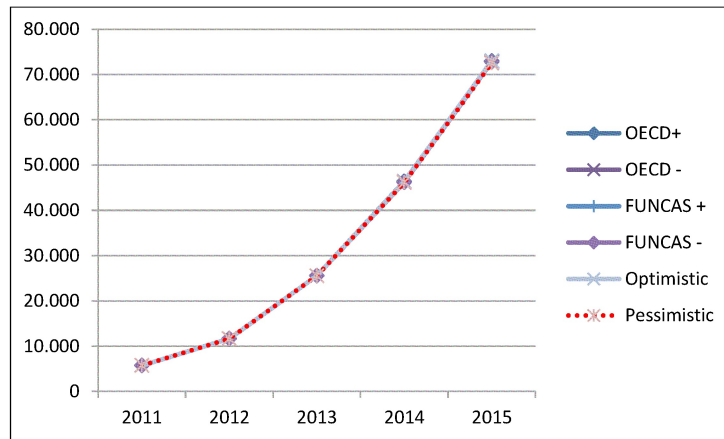
Source: Own performance.

2.3.2 Sensitivity analysis of the proportionality ratio of the contagion parameter γ_2

In the model construction we assumed that the propagation parameter γ_2 was two times the value of γ_1, knowing that $\gamma_2 > \gamma_1$. As it is uncertain how much bigger is γ_2 than γ_1, it is advisable to perform a sensitivity analysis of this proportionality factor between both parameters. Following we are going to simulate the number of non-competitive body-builders with MD under a variation of the proportionality factor, considering the interval $[1,3]$, this is from the situation $\gamma_2 = \gamma_1$ to $\gamma_2 = 3 \times \gamma_1$.

The simulations were made assuming that all parameters remain constant and the rate of unemployment applied was the annual average rate of unemployment of all possible economic scenarios considered (i.e.,$OECD+$, $OECD-$, $FUNCAS+$, $FUNCAS-$, optimistic, pessimistic).

Results are shown in figure 2.8. Note that for a fluctuation of the social contagion parameter γ_2 between the interval $[1,3]$ the prevalence rate of non-competitive bodybuilder with MD fluctuates between the intervals $[6.70\%, 15.87\%]$.

Figure 2.8: Sensitivity analysis of γ_2 for non-competitive bodybuilder with MD (A) subpopulations in 2015.
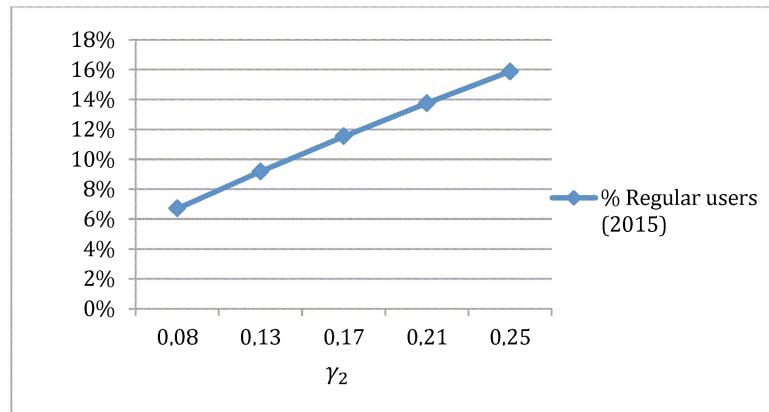
Source: Own performance.

2.4 Conclusions

The present study allows the forecast of the volume of Spanish non-competitive bodybuilders at risk to be affected by MD in the period of study $[2012, 2015]$. The development of the mathematical population model takes into account demographic, economic, emotional and behavioral factors and splits the target population into three categories according to the amount of non-competitive body builder practice and their psychological dependence measured by the questionnaire TBV (Baile, 2005). This population model is founded on the human behavior of herding and social propagation (Christakis and Fowler, 2009; Rafaat, 2009) and the study of the dynamic transits between subpopulations along the period of study.

As some of the coefficients such as the social contagion effect are difficult to be accurately measured, we use the data from the subpopulations quantities in two different instants of time and the response of the model in order to match the uncertain coefficients.

In order to increase the reliability of our results, we developed a sensitivity analysis by studying the change of the results versus the variation of the social propagation parameter. From our results we can conclude that our model is robust.

One of the main advantages of this model is the possibility to be applied to any other western country where data are available as well as to another period of study in which the hypotheses remain applicable.

Unlike previous studies mainly qualitative and statistical searching for the main drivers as well as the construction of appropriated questionnaires and their validation (Pope *et al.,* 2000b; Olivardia, 2001; Kanayama *et al.,* 2006; Hildebrandt *et al.,* 2006), this study quantifies the volume of non-competitive bodybuilders practitioners and bodybuilders at risk to suffer MD in the next years. Also, by first time we introduce in the study of the MD the sociological influences such as the human herding and social propagation (Christakis and Fowler, 2009; Raafat *et al.,* 2009).

The social contagion has been also used to explain the propagation of some socio-epidemics such as obesity (Christakis and Fowler, 2007) or compulsive shopping (García *et al.*, 2011).

For the sake of honesty we should acknowledge that one limitation of our study proceed from our hypotheses about the quantification of the influence of emotional status in the non-competitive body builder practice as well as the approximated age intervals when the male becomes economically self-sufficient, (see coefficient α_e). Due to lack of official data about the Spanish coupling rate, embracing those who are married but also those who are non-officially registered couples (or separations), the rate of Spanish coupling (or separations) is conservative estimated since we just considered the official data provided by the Spanish marriage rate (or Spanish divorce rate).

Chapter 3

**Mathematical modeling of the low-invasive consumption
of plastic surgery practices**

Summary

Plastic surgery among women grows continuously in Western countries due to body image dissatisfaction, aging anxiety and the ideal body image propagated by media. The consumption growth is so important that the plastic surgery is becoming a normal practice among women, like other cosmetic products, with the risk of suffering psychopathology disorders in the sense that plastic surgery could be regarded as an instrument to recover personal self-esteem, or even happiness.

Plastic surgery depends on economic, demographic and social factors. In this chapter a mathematical model to forecast the female plastic surgery consumption in Spain is fully constructed. Population of over-consumers is predicted and simulated. Robustness of the model versus uncertain parameters is studied. .

3.1 Introduction

Society pressures women continuously to be eternally young and beautiful. The Botox® or Botulinum toxin and fillers (hyaluronic acid) but also others that involve low invasive procedures such as restylane, juvederm, chemical peelings, prevelle, rosacea treatments, and vampire facelift have shown a fast growth during last decades; these concern to the anti-aging treatments such as face wrinkle and eyelid and are nonsurgical procedures. This sector has grown from 91 million dollar per year in 1997 to 1.8 billion in 2012 (TAC, 2012). These non-surgical plastic procedures are related to psychological drivers, but also to economic ones due to their low costs versus others procedures like augmentation of breasts or butts. The fast growth of the consumption of these procedures makes these practices become affordable and not luxury, as consequence of the bandwagon (Kastanakis and Balabanis, 2012), and therefore closely related to the economic situation measured by the Spanish unemployment rate. Furthermore, apart from the economy, people changes because of emotional waves and social influences (media, mimetic behavior, social contagion).

In the global framework, USA leads the world ranking in volume of procedures, approximately 14.6 million in 2012 (including both non-surgical and surgical ones). The most important non-surgical procedures in terms of volume is the Botox® (Botulinum toxin treatment) with more than 13 million treatments performed in USA in 2012, showing an annual increase about 6% (ASPS, 2014); in turnover, the sector reached the amount of \$11 billion in USA in 2012 (ASAPS, 2012).

Otherwise the second market for plastic surgery after USA, is the European market which reached about \$2.2 billion with a Compounded Annual Growth rate ($CAGR$) 19% (Frost & Sullivan, 2008); it will be expected to reach \$3 billion by 2015. Of first market in the European area reveals United Kingdom UK according to British Association of Aesthetic Plastic Surgeons ($BAAPS$) with 43 172 surgical procedures carried out by $BAAPS$ showing an increase of 0.25% from the previous year (BAAPS, 2013). The market was estimated nearly to £2.3 billion in 2010 and assumed it will be rise to £3.6 billion (Molina *et al.;* 2012).

In Spain, there isn't any accurate statistical data from public institution about the plastic surgery procedures. However, according to the survey published by $ISAPS$, Spain occupied $12th$ in the ranking of world plastic surgery procedures (ISAPS, 2014). The estimated number of annual procedures of plastic surgery performed to women in Spain was 150 000 in 2009 (EUROPA PRESS, 2012). After Botox® treatments breast augmentation is the most relevant treatment in numbers of procedures, even increasing during the economic recession.

Also, the most recent report reveal the sector declined its turnover from 2007 to 2012 by 45% (La voz de galicia, 2012 ; EUROPA PRESS, 2013; DBK, 2013); the number of plastic surgery clinics reach to 480 in Spain in 2011; the economic downturn lead clinics

to close. Moreover, in 2010 the volume of turnover amounted to 192 million Euros, then it decreased slightly again in 2011 to 190 million Euros and it continued to decline until 180 million Euros in 2012 (DBK, 2013).

Human beings could be understood as a combination of animal and spirit. When people suffer from low self-esteem's levels they try to improve their well-being by over-practicing those activities that make them feel better. These psychological factors are one of the motivations that explain the growth of social addictions like plastic surgery.

However, even when these procedures are becoming regular goods of consumption of western societies average economic behavior (11% unemployment rate, for Spain), for the particular case of Spain, deeply affected by the economic crisis (27% unemployment rate in 2013), the emergence of these products is slowing down due to the crisis.

Forecasting the growth of plastic surgery female population (Molina *et al.,* 2012) is interesting from the economic point of view as an emergent business in the western societies but also relevant from the point of view of public health due to the potential abuse of these practices as artificial tools to enhance personal self-esteem and confidence (De Aquino, 2013).

In this chapter, we constructed an epidemiological discrete mathematical model to forecast the population of female consumers of non-surgical plastic surgery in the coming years in Spain. We deal with populations more than individuals. Individual human behavior may be erratic, but aggregated behavior is often quite predictable, (MacCluer, 2000). The population model approach is also founded on the mimetic human behavior (Girard, 1988), human herding (Raafat *et al.,* 2009) and social contagion (Christakis and Fowler, 2009).

Epidemiological mathematical models have been employed during last years to describe the propagation of several social disorders such as the consumption of substances like alcohol, cannabis, tobacco, etc (Santonja *et al.,* 2010a; Guerrero *et al.,* 2013) as well as the development of habits like compulsive shopping, workaholism, bigorexia, and sex-addiction, eating disorders (García, *et al.,* 2011; De la Poza *et al.,* 2013a; Baile, 2005; Santonja *et al.,* 2010b; Christakis and Fowler, 2007).

This chapter is organized as follow: The first Section 3.1 shows the introduction about this sector. The second section 3.2 of this chapter is devoted to the construction of a questionnaire that will allow us to classify the collected data into subpopulations. Section 3.3 is focused on the construction of a system of difference equations whose solution will permit forecast the population of consumers in the next years. Section 3.4 shows the conclusions.

3.2   Sources of Information and Methodology

3.2.1   A questionnaire measuring the level of surgery practice

Typically there are two main ways to produce questionnaires to measure the level of consumption of a good or service, those questionnaires focused on the amount of activity performed (Heatherton, 1991) or those focused on the psychological dependence of the consumer (García, 2007; De la Poza *et al.,* 2013a). Hybrid questionnaires combined both parameters to produce an appropriated questionnaire (Pope *et al.,* 2000a).

In this section we design a questionnaire for measuring the level of consumption of plastic surgery procedures. Although our questionnaire does not distinguish among surgical and non-surgical treatments, we assume that fearless women to practice surgical treatments are also potential consumers of non-surgical practices.

In the questionnaire we include several demographic questions a part from the related to the aesthetic surgery practice, which will play an important role in the sociological study of the subpopulations.

3.2.2   Data collection and sampling

The population of the study is composed by the Spanish women who undergo to practice plastic surgery aged among the interval $[16, 60]$.

We passed the questionnaire once, (Late of March 2012) at different locations such as a private gym also a private franchised gym multi-located and a public beach of Valencia. Participants were asked to complete a questionnaire composed by 8 questions. Each answer had two and/or three possible answers; questions from 1 to 5 were related to socio-demographic data while questions from 6 to 8, were related about the practice. The classification of the individuals is based on the answer of question number 7 (see Appendix $C.B$ and $D.B$):

- R: Defined as rational women when their score at question 7 was 0 or 1 at year n.

- O: Over-consumer women whose answer at question 7 was equal to 2 or 3 at year n.

- D: Women who scored higher than 3 at question 7 are considered dependent consumers at year n.

Question number 6 is related to the social contagion, which will be relevant in the model construction. Question number 8 focuses on the willingness to practice plastic surgery.

Following table (3.1) shows data collected in our sample classifying the Spanish women by subpopulations after applying stratified sampling using data from the Spanish Statistical Institute (INE).

		2012	
	Sample	Spanish women by population	
R	213	13 730 450	
S	11	709 084	
A	2	128 924	
Total	226	14 568 458	

Table 3.1: Data collection and Spanish population distribution for 2012.

3.2.3   Constructing the mathematical model

The purpose of this section is to develop a discrete mathematical model, which allows us to forecast the Spanish women's low-invasive plastic surgery procedures ($LIPS$) for the interval $2012 - 2018$.

As it was commented in the previous section, the population object of study was divided into three categories according to their answer to question number 7, that measures their amount of consumption.

Our attention is focused on forecasting the number of rational plastic surgery consumers (R), over-consumers of plastic surgery (O) and the dependent (D) to low-invasive plastic surgery procedures.

The low-invasive plastic surgery behavior is dynamic which means changes over time, and embraces interactions among subpopulations. For this, a mathematical model is going to be constructed to describe this dynamic as a system of difference equations whose unknowns are the following subpopulations:

$R(n)$ = Number of rational-consumers who undergo plastic surgery procedures, aged among the interval $[16, 60]$ at year n.

$O(n)$ = Number of over-consumers of plastic surgery practice aged among the interval $[16, 60]$ at year n.

$D(n)$ = Number of dependent-consumers of plastic surgery practices aged among the interval $[16, 60]$ at year n.

The total population (P) in the time n is given by:

$$P(n) = R(n) + O(n) + D(n) \tag{3.1}$$

As at any other western developed country the Spanish birth and mortality rate are quietly balanced what makes the total population does not increase in a significant degree (INE). However, for the particular case of Spain, due to the ferocious economic crisis (actually, 27% unemployment rate; 57% youth unemployment rate) we have exceptional emigration events: firstly, jobless immigrants are returning to their countries of origin but also unemployed Spanish citizens are emigrating looking for a job abroad.

In particular, the impact of the crisis over the Spanish economy, $200\,000$ foreign immigrants are coming back to their countries yearly. In addition, about $100\,000$ Spanish citizens leave yearly Spain seeking for a job overseas (Sánchez, 2013). Both facts involve a net decrease of the Spanish population of about $350\,000$ people per year and approximately $175\,000$ women. Disregarding under 16 years old people, we estimate that about $300\,000$ older than 16 years old people leave Spain every year since 2012 until 2018. Thus, the amount of approximately $E = 150\,000$ women leave Spain yearly during the considered period of study.

The dynamic behavior of the low-invasive plastic surgery practices is based on subpopulations' transits explained by coefficients that need to be modeled according to economic, socio-demographic and contagion hypotheses, but also collected data analysis.

The period of study started in 2012, when the first sample of the study was obtained and finishes in 2018. People behavior changes along the time, not only because of biology but also because of external influences (media, contagion, mimetic behavior, human herding and economy) and psychological drivers (low self-esteem, poor well-being and self-confidence). This motivates the consideration of subpopulation transits that are computed throughout sociological analysis and assuming behavioral hypotheses.

Then, the dynamics between subpopulations R, O and D are estimated for the interval $[n, n+1]$.

a The influence of an economic change could cause the transit of women between categories R, O and D following the economic trend, $\alpha_e(n)$ and $\beta_e(n)$. We estimated from the annual survey on Aesthetic procedures provided by $ISAPS$ (2013), the relationship between the economic behavior throughout the Spanish unemployment rate and women who underwent plastic surgery.

b The contagion effect based on low levels of self-esteem combined with the mimetic behavior, social contagion, bandwagon (Girard, 1988; Christakis and Fowler, 2009, Raafat *et al.,* 2009; Kastanakis and Balabani, 2012) leading to the transit from R to

O and also from O to D due to the contact between women who underwent $LIPS$, γ_1.

The dynamics of the model are described by the following equations:

$$
\left.
\begin{aligned}
R(n+1) &= \left(1 + \alpha_b(n-16) - \tfrac{d_i+\alpha_f}{3}\right) R(n) - \alpha_r R(n) \\
&\quad - \alpha_e(n)R(n) - \gamma_1 R(n) - E, \\
O(n+1) &= \left(1 - \tfrac{d_i+\alpha_f}{3}\right) O(n) + \alpha_e(n)R(n) + \alpha_r R(n) \\
&\quad - \beta_e(n)O(n) + \gamma_1(R(n) - O(n)), \\
D(n+1) &= \left(1 - \tfrac{d_i+\alpha_f}{3}\right) D(n) + \beta_e(n)O(n) + \gamma_1 O(n).
\end{aligned}
\right\}
\tag{3.2}
$$

The dynamics of the model (Figure 3.1) is shown in the diagram:

Figure 3.1: Block diagram of the system's dynamics.
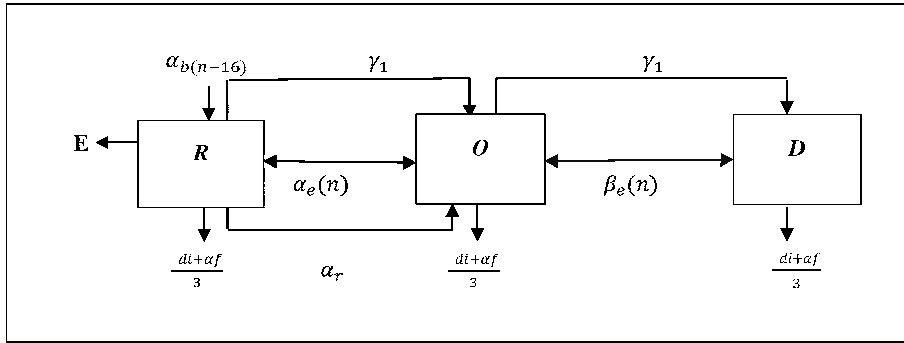
Source: Own performance.

The values of all parameters were estimated from different sources of information and hypotheses with the exception of the transit α_r and γ_1 obtained from the Spanish Statistical Institute (INE) and the survey designed and implemented in this study. In the following, we describe the construction of the parameters of the model.

- $\alpha_b(n-16)$: It is the birth rate of the Spanish population at year $(n-16)$. This parameter is estimated according to the data coming from the Spanish Statistical Institute (INE). We assume that all women becoming 16 year old women in Spain entry into the system as rational consumers.

- $\frac{d_i+\alpha_f}{3}$: Then, the exit from the system could happen due to two reasons: the biological death measured throughout the rate of death (d_i) of women up to 60 years old, as well as (α_f) are those women aging 61 years old and older. α_f are women who become out of our age period interval estimated as a half of the Spanish birth rate at the year $(n - 61)$ is constant. Due to the lack of reliability of the available information, we assume that the system death probability is the same for both three categories.

- α_r: Is the recovery rate of self-esteem. The coefficient is split into two components α_{r1} and α_{r2}.

  1. α_{r1}: The rate of rational Spanish consumers of Botox ®$(C = 0.49\%)$(Ruiz Rodríguez, 2009),we estimated an 8% (Etcoff *et al.,*2006) of the rational Spanish women aged in the interval $[30, 45]$ years old were treated with Botox® looking for a better physical image, but also 1% did it in order to overcome some emotional drawback. We weighted α_{r1} as 2/3 of α_r. In general, women between that age intervals $[30, 45]$ are more interested in taking care of their physical appearance what justifies the weight $2/3$.

  $$= 0.42 \times 0.004924787 \times (0.08 + 0.01) \times 2/3 = 0.000124105$$

  2. α_{r2}: Again, we estimated that from the proportion of Spanish women that underwent Botox® treatments (0.49%), those who were among the age interval $[46, 60]$ were treated looking for a better body image, and for improving their well-being after suffering from emotional slowdowns; about one third of the 35% of the divorced Spanish women underwent these plastic surgery procedures.

  $$= 0.32 \times 0.004924787 \times (0.35) \times 1/3 = 0.000183859$$

  $$\alpha_r = \alpha_{r1} + \alpha_{r2}$$

  Then,

  $$\alpha_r = \alpha_{r1} + \alpha_{r2} = 0.000124105 + 0.000183859 = 0.0003079695$$

  The distribution of weights, two thirds versus one third between both coefficients α_{r1}, α_{r2} is based on the hypothesis that in western countries like Spain, women aged in the interval $[30, 45]$, use to be more concerned about their physical appearance.

- $\alpha_e(n)$: The impact of the economy measured in terms of the annual Spanish unemployment rate $\delta(n)$, allowing the transit between subpopulations bidirectionally according to the economic trend as it occurs with most of consumption goods.

  Observing the behavior of both the Spanish economy but also the Spanish $LIPS$

data consumption (ISAPS, 2013) and the approximated distribution of the consumers among the three categories (R, O, D), during the full economic crisis period $2009 - 2011$ we suggest an approximated correlation of both variables quantified as follows:

If the unemployment rate increases by 1%, the consumption of $LIPS$ decreases by 3%. In addition, we should consider which are the transits in periods of economic recovery. However, after a long period of economic crisis in Spain, the recovery of consumption habits is slow particularly the consumption of products and services related to the body care.

We assume that if the unemployment rate $(\delta(n))$, improves 1% the $LIPS$ consumption recovery is 1% until the economic scenario achieves a stable admissible (11% unemployment rate) situation. This transit only affects to the categories R and O.

The coefficient is modeled as follows:

$$
\alpha_e(n) = \begin{cases}
3 \times (\delta(n-1) - \delta(n))C, & \text{if} \quad \delta(n) > \delta(n-1), \\
-1.5 \times C, & \text{if} \quad \delta(n) = \delta(n-1), \\
0.5 \times (\delta(n-1) - \delta(n))C, & \text{if} \quad \delta(n) < \delta(n-1).
\end{cases} \tag{3.3}
$$

The consumption of this kind of products is differently affected by the category of consumers. The dependent consumer behavior is influenced by psychological factors. Indeed, the D consumer reacts differently than an R or O consumer to any change in the economic environment. Thus, we assume that the transit coefficient $\beta_e(n)$.

$$
\beta_e(n) = \begin{cases}
4 \times (\delta(n-1) - \delta(n))C, & \text{if} \quad \delta(n) > \delta(n-1), \\
-2 \times C, & \text{if} \quad \delta(n) = \delta(n-1), \\
2 \times (\delta(n-1) - \delta(n))C, & \text{if} \quad \delta(n) < \delta(n-1).
\end{cases} \tag{3.4}
$$

In the present economic context of crisis, when Spanish unemployment rate is higher than 20%, the propagation of the consumption of $LIPS$ only affects to the segment of women with secured incomes or wealthy people. According to our survey, women interacts on a daily bases with 30 other females, from those, 1 belongs to the category O or D (3.3%) (Park *et al.,* 2009; Christakis and Fowler, 2009; Rafaat *et al.,* 2009) This fact suggests a contagion rate of $\gamma_1 = 0.033 \times C$. We assume this parameter is constant all the time, but also this is a continuous jump

contagion; people only jump from one category to the next level of consumption
($R \longrightarrow O; O \longrightarrow D$).

- $E = 150\,000$: Is the constant approximated value of women that leave Spain looking for a job abroad due to the economic crisis. We assume all of them are rational potential consumers of plastic surgery procedures.

3.3 Results and Simulations

3.3.1 Results of the model

The mathematical model allows us to predict the subpopulations $R(n)$, $O(n)$ and $D(n)$ at any year n, in the study interval $[2012 - 2018]$. In order to compute the subpopulations it was necessary to estimate the coefficients of the system for the next years according to two economic scenarios, one more optimistic and other one more pessimistic, reflecting the Spanish economic trend.

Thus, we based our pessimistic scenario on the economic forecast of the Spanish unemployment rate according to the Organization of Economic Cooperation and Development (OECD, 2013) for the years 2011 and 2014 and for the optimistic scenario from the International Monetary Fund for the period $[2011 - 2018]$ (IMF, 2013). For 2015 we applied the rate of unemployment predicted by Société Générale (SG, 2013) for the pessimistic scenario, while we forecasted by ourselves the economic trend for the period $[2016 - 2018]$, (see table 3.2).

Since organizations only forecast the Spanish unemployment rate until 2015 (Société Générale, 30%), we continue the predictions of the Spanish economic scenario following the $OECD$/Société Générale forecast with a more pessimistic scenario while the IMF one agrees with a more optimistic approach.

	Pessimistic	**Optimistic**
2011	21.6	21.7
2012	25.0	25.1
2013	26.9	27.0
2014	28.1	26.0
2015	30.0	24.7
2016	29.0	23.2
2017	28.5	21.7
2018	28.0	20.1

Table 3.2: Economic forecast of the annual Spanish unemployment rate expressed in percentage. Source: Own performance from data available by $OECD$, SG and IMF.

Once the economic scenarios were built, we estimated the annual value of each subpopulation $R(n)$, $O(n)$ and $D(n)$. Table 3.3 collects the results performed by the computation of the system expressed in absolute terms (number of women at each subpopulation at year n).

	Pessimistic			Optimistic		
	R	O	D	R	O	D
2011	13 778 952	711 589	129 379	13 778 952	711 589	129 379
2012	13 669 723	707 090	128 118	13 669 743	707 071	128 211
2013	13 558 991	705 473	127 079	13 559 067	705 403	127 261
2014	13 444 811	705 099	126 139	13 442 149	707 531	126 651
2015	13 336 065	703 400	125 109	13 329 129	709 665	126 067
2016	13 227 621	705 431	124 418	13 220 562	711 780	125 500
2017	13 120 360	707 266	123 697	13 112 952	713 827	124 938
2018	13 014 809	709 038	122 980	13 007 344	715 578	124 317

Table 3.3: Subpopulation forecast in number of women who practice $LIPS$ by economic scenarios.

In table (3.4) we show the trend of subpopulations expressed in percentage according to the economic scenarios.

	Pessimistic			Optimistic		
	R	O	D	R	O	D
2011	94.24%	4.86%	0.8849%	94.24%	4.86%	0.8849%
2012	94.24%	4.87%	0.8832%	94.24%	4.87%	0.8839%
2013	94.21%	4.90%	0.8830%	94.21%	4.90%	0.8842%
2014	94.17%	4.93%	0.8835%	94.15%	4.95%	0.8871%
2015	94.15%	4.96%	0.8832%	94.09%	5.01%	0.8899%
2016	94.09%	5.01%	0.8850%	94.04%	5.06%	0.8927%
2017	94.04%	5.06%	0.8866%	93.98%	5.11%	0.8955%
2018	93.99%	5.12%	0.8881%	93.93%	5.16%	0.8977%

Table 3.4: Results of the model according to the pessimistic and optimistic economic scenarios.

Figures 3.2, 3.3 and 3.4 illustrate the results of the model.

Figure 3.2: Simulated subpopulations of rational-consumer (R) during the period [2011-2018] by economic scenarios.
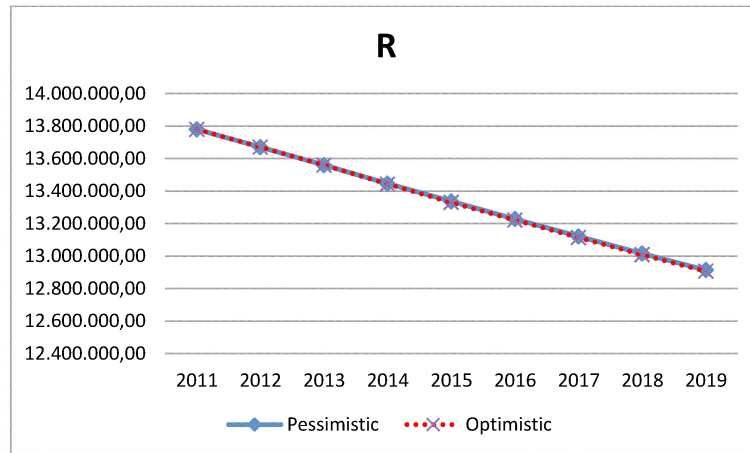
Source: Own performance.

Figure 3.3: Simulated subpopulations of over-consumer (O) during the period [2011-2018] by economic scenarios.

Source: Own performance.

Figure 3.4: Simulated subpopulations of dependent-consumer (D) during the period [2011-2018] by economic scenarios.
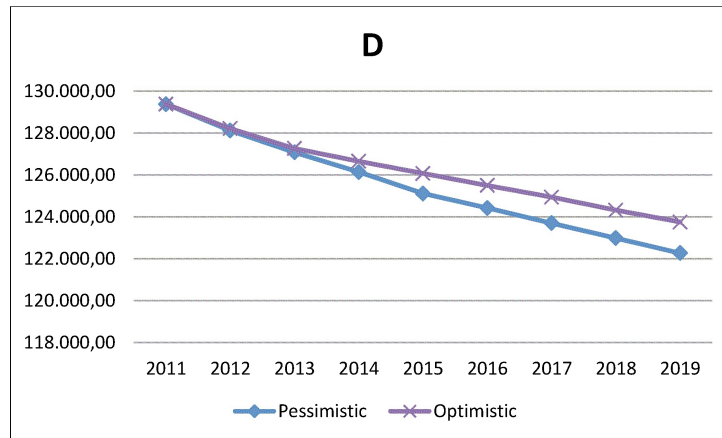
Source: Own performance.

Even when the consumption of these products show a growing trend, the level of activity of these services slows down between the middle class due to the hard Spanish economic crisis.
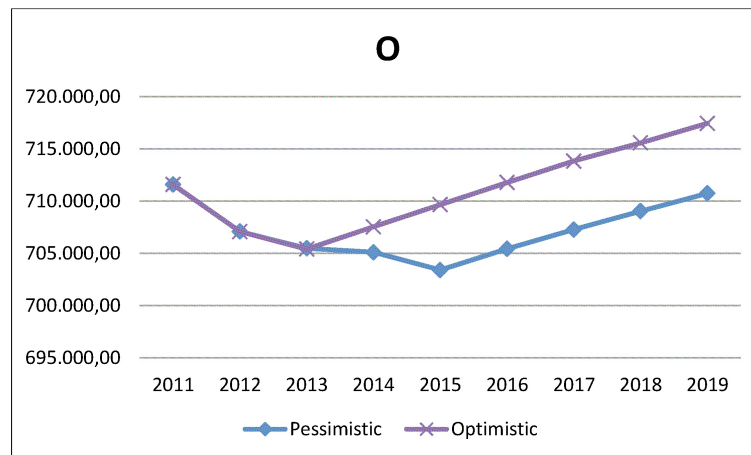
3.3.2 Sensitivity analysis of the contagion parameter C

Then, we performed a sensitivity analysis of both models (pessimistic and optimistic) versus the contagious parameter C, involved in the coefficient $\gamma_1 = 0.033 \times C$. Results showed the same effect for both economic scenarios. In fact, regarding a variation interval for C ranging in the interval $[0.0049, 0.1]$, where the extreme value 0.0049 corresponds to the current consumption rate of $LIPS$ by Spanish women whereas the highest value 0.1 would correspond to a situation where middle class sums up to the imitation effect and the consumption of this type of goods. Figure 3.5 illustrates how the subpopulations vary continuously with the contagion parameter measured in terms of C with robustness.

Figure 3.5: Sensitivity analysis of subpopulations versus the contagion parameter for the optimistic scenario. (Abscises represents values of the parameter C).
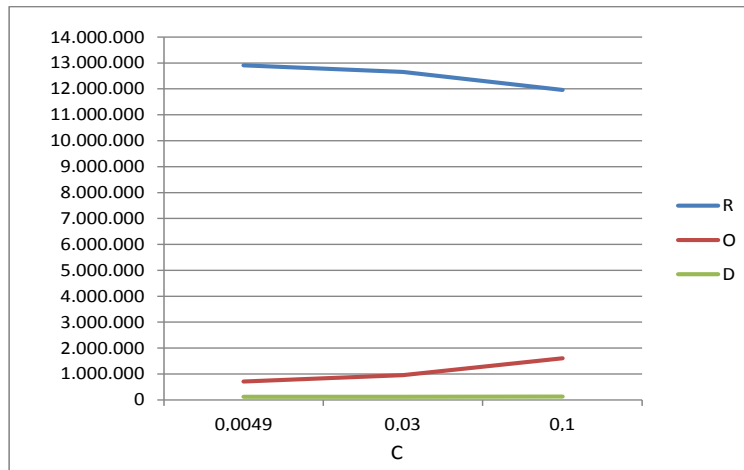
Source: Own performance.

3.4   Conclusions

In this study, a complete mathematical model for predicting the low-invasive consumption of plastic surgery practices ($LIPS$) in Spain during the period $[2012 - 2018]$ has been constructed.

To our knowledge this is the first time the consumption of these services has been modeled from a behavioral perspective, although some statistics about the level of consumption may be found in the literature. However, previous studies focused on the willingness to consume $LIPS$ rather than forecasting real consumption $LIPS$. As consequences, our results are conservative, since we predict $LIPS$ activity, we are taking into account economic environment, individual contagion and emotional derives.

The $LIPS$ consumption improves the possible professional success, the well-being of the person, improving her body image and social skills. However, it is important to point out that an over-consumer of these practices can lead to a social disorder of dependence and identification of happiness by care of the body.

Thus, from the point of view of business and marketing it is interesting to study the propagation of these services while from the public health point of view it is interesting to

study the evolution of the over-consumers and addicts.

Our discrete mathematical model is of epidemiological nature, where consumers are classified by subpopulations according with a survey designed by the authors in this chapter.

The study of the consumption of this product in Spain is particularly interesting due to several reasons; firstly because of the emergency of its consumption by middle classes in western countries as any other service employed to body care during last decade. However, the impact of the ferocious Spanish economic crisis slowed down suddenly its trend to the break-even point where these services are just affordable by high-income women.

The model allows the possibility of simulating artificial scenarios simply by changing the values of the parameters and computing the subpopulations with the model. Furthermore, the model is applicable to any other region where economic and sociological data is available.

In addition, the model has the potential advantage that the period of study can be modified assuming a lost of accuracy due to the uncertainty of the economic future.

Chapter 4

Mathematical modeling of the high-invasive plastic surgery practices

Summary

In this chapter we develop a mathematical model to forecast the high-invasive plastic surgery ($HIPS$) consumption in Spain. We simulate possible economic scenarios. Our results show an increasing trend of occasional and regular women $HIPS$ consumers independently of the economic situation.

4.1   Introduction

Cosmetic procedures as we known in the previous chapter **??** can be classified into two categories surgical and non-surgical. While non-surgical procedures are low-invasive treatments such as botox®, chemical peelings, prevelle, rosacea treatments and vampire facelift. The surgical ones are more aggressive from a medical point of view what is associated to greater healthcare risks and require hospitalization (Sarwer and Crerand, 2004).

The difference in the level of medical-invasion between both categories (Low-Invasive Plastic Surgery ($LIPS$) and High-Invasive Plastic Surgery, ($HIPS$)) explains the $LIPS$ are cheaper and as consequence more affordable than $HIPS$ which are more expensive.

The $HIPS$ category embraces procedures such as breast augmentation, breast reduction, rhinoplasty and liposuction. The consumption of $HIPS$ has been traditionally related to women in western societies (Swami *et al.,* 2005b). However, recent studies show an increase of men consumption (Grant, 2012).

The drivers that explain the consumption of $HIPS$ are of different nature. We can group them into three kinds: economic (Nassab and Harris, 2013) psychological (Sarwer *et al.,* 1998) and contagion effect (Raafat *et al.,* 2009). As any other consumption good, $HIPS$ consumption is affected by the economic-cycle; thus, there is a positive relation between the real net income and the number of $HIPS$ performed (Paik *et al.,* 2013) but also the $HIPS$ demand is influenced by the access to the credit what depends on the financial markets stability (Nassab and Harris, 2013).

At the present time, Spain is impacted by a ferocious economic and financial crisis with stable unemployment rates over 21%. In this context, it would be expected a decrease of $HIPS$ consumption, however two opposite forces emerge: women looking for a physical improvement throughout $HIPS$ procedures as a tool for achieving professional success (Sarwer *et al.,* 2003); also, any economic crisis increase unequal income distribution (Duncan *et al.,* 2004) producing the expansion of demand from wealthy women, (mainly $HIPS$ consumers) while consumption from middle class decreases, (more oriented to $LIPS$ consumption, (De la Poza *et al.,* 2013b). Psychological effects that drive women to practice $HIPS$ can be explained as a mechanism to recover their well-being and personal satisfaction with their physical appearance (Swami *et al.,*2008).

Also, the contagion effect promoted by media, (TV, marketing and advertising.....etc) that spreads the message of perfect bodies (diets (Coughlin *et al.,* 2012), muscular (Leone *et al.,* 2005) and breast boobs (Henderson-King and Brooks, 2009)) but also by the interactions among women that practice $HIPS$ regularly with those that do not, producing the propagation of the consumption of this product.

The aim of this chapter is to develop a mathematical model to forecast the future consumption rate of high-invasive plastic surgery in Spain over the next five years. To our

knowledge $HIPS$ consumption or practice, neither any study that models and predicts the level of consumption of this sector of economic activity.

The chapter is organized as follows: Section 4.1 presented the introduction. The section 4.2 deals with the model construction throughout a discrete system of different. In Section 4.3 computations and simulations are carried out after assuming several possible economic scenarios for the next coming years. Section 4.4 shows the conclusions.

4.2 Mathematical Model Construction

4.2.1 Data collection and sampling

The population of the study consists of Spanish women who underwent $HIPS$ aged among the interval $[16, 60]$.

We classified the population into three categories depending on their level of activity measured throughout a survey carried out for this purpose.

The three categories were defined according to $HIPS$ women consumption as follows:

- $P(n)$: Defined as rational women when their level of consumption was equal to 0 times at year n.

- $O(n)$: Defined as occasional-consumers when they practiced $HIPS$ just 1 time at year n.

- $R(n)$: Is defined as regular-consumers when their $HIPS$ practice was higher than 1 time at year n.

4.2.2 Mathematical model

The dynamic behavior of the $HIPS$ procedure is based on their transition among sub-populations explained by coefficients that need to be found according to economic, psychological and social propagation hypotheses. Our attention is focused on forecasting the number of $HIPS$ consumption for the period $[2012 - 2016]$.

We passed the questionnaire once, (Late of March 2012) at different locations such as a multi-located private gym also a private franchised gym and a public beach. Then, with the result obtained from the survey, we adjust the Spain women population into three sub-population using data from (INE, 2012).

Hypothesis of the model

a. The influence of the economy affects differently the subpopulations causing transits between them. There is a transit due to the economy from $P \longrightarrow O$, $\alpha_e(n)$. Therefore, an economic worsening produces that only the high and stable income women transit from $O \longrightarrow R$, $\alpha_{e1}(n)$.

b. The propagation effect caused by the personal relationship between P and O subpopulations producing the transit from $P \longrightarrow O$ and also, from $O \longrightarrow R$, α_c and $\frac{\alpha_c}{2}$.

The dynamics of the model figure 4.1 is shown in the diagram:

Figure 4.1: The dynamic of population who underwent $HIPS$.
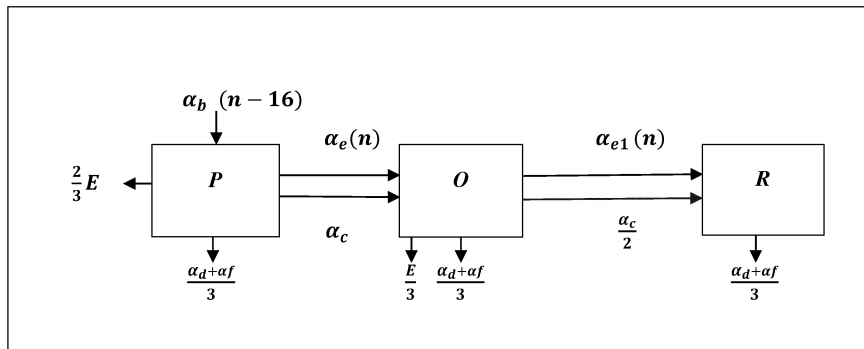
Source: Own performance.

Thus, the dynamic model of the $HIPS$ consumer's propagation can be modeled by the following equations:

$$H(n) = P(n) + O(n) + R(n). \tag{4.1}$$

$$
\left.
\begin{aligned}
P(n+1) &= \left(1 + \alpha_b(n-16) - \frac{\alpha_d+\alpha_f}{3}\right)P(n) - \alpha_c P(n) \\
&\quad - \alpha_e(n)P(n) - \frac{2}{3}E, \\
O(n+1) &= \left(1 - \frac{\alpha_d+\alpha_f}{3}\right)O(n) + \alpha_e(n)P(n) + \alpha_c P(n) \\
&\quad - \alpha_{e1}(n)O(n) - \frac{\alpha_c}{2}O(n) - \frac{E}{3}, \\
R(n+1) &= \left(1 - \frac{\alpha_d+\alpha_f}{3}\right)R(n) + \frac{\alpha_c}{2}O(n) + \alpha_{e1}(n)O(n).
\end{aligned}
\right\}
\tag{4.2}
$$

Parameters of the model

The values of all parameters were computed from different sources of information and hypotheses as follows:

- α_c = 0.027 is the annual contagion rate. The contagion effect is based on low levels of self-esteem combined with the mimetic behavior (Raafat *et al.,* 2009) that incentives the transit from $P \longrightarrow O$ and for the transit from $O \longrightarrow R$, $\frac{\alpha_c}{2} = \frac{0.027}{2} = 0.0135$ due to contact between women. However the contagion effect of $HIPS$ practice is also related to the economic situation. As consequence, we estimate that from the period of time $2009 - 2011$, there has been an average annual increase of the unemployment rate of 2.5% following, while the $HIPS$ practice has increased annually a 2.7% (ISAPS, 2012; OECD, 2013). Assuming a conservative economic scenario in which the unemployment rate remains stable or even starts decreasing, the contagion rate is considered constant for the period of study. We estimate O subpopulation is less impacted by the contagion effect due to their previous $HIPS$ experiences.

- $\frac{2}{3} \times E = \frac{2}{3} \times 150\,000 = 100\,000$ is the constant approximated value of Spanish women that leave Spain looking for a job abroad due to the economic crisis. Furthermore, $E = 150\,000 \div 3 = 50\,000$ are the occasional-consumers that leave Spain due to the crisis. We assume these values remain constant for the period of study. Also, we assume R subpopulation are high-income Spanish women who do not leave Spain since they are minimally affected by the crisis.

- $\alpha_e(n)$ and $\alpha_{e1}(n)$ are the economic effects on women who undergo plastic surgery. We assume than an economic improvement (decrease of unemployment rate) produces an increase of the $HIPS$ and vice versa. When the economy is worse only rich women practices plastic surgery. The economic effects came from two possible situations:

- Firstly, when the unemployment rate decreases 1%, there is an increase of 0.027% $HIPS$ practice of the total Spanish women. If the rate of unemployment increases of 1% there is no transit. Following these conditions are expressed for occasional-consumers:

$$
\alpha_e(n) = \left\{
\begin{array}{ll}
-0.027 \times (\rho(n+1) - \rho(n)) & \text{if} \quad \rho(n+1) < \rho(n), \\[2mm]
0 & \text{if} \quad \rho(n+1) \geq \rho(n).
\end{array}
\right. \tag{4.3}
$$

Where $\rho(n)$ is the Spanish unemployment rate in percentage at year n.

- Secondly, when the economy deteriorates, just rich women practices plastic surgery. For every 1% increase in unemployment, the $HIPS$ consumption increases 0.001%. We assume 0.001% remains constant for the period of study. However, when the unemployment rate decreases 1% the consumption of $HIPS$ increase 0.026%.

$$
\alpha_{e1}(n) = \left\{
\begin{array}{ll}
0.001 \times (\rho(n+1) - \rho(n)) & \text{if} \quad \rho(n+1) \geq \rho(n), \\[2mm]
-0.026 \times (\rho(n+1) - \rho(n)) & \text{if} \quad \rho(n+1) < \rho(n).
\end{array}
\right. \tag{4.4}
$$

Where $\rho(n)$ is the Spanish unemployment rate in percentage at year n.

4.3   Results and Simulations

The mathematical model is helping us to predict the subpopulations $P(n)$, $O(n)$ and $R(n)$ at any year n.

We assumed the economic forecast from (OECD, 2012; SG, 2013; IMF, 2013) from 2011 until 2016. We introduced two economics scenarios one optimistic and one pessimistic for the total period of study; thus, any possible economic situation is enclosed in the range of variation of our scenarios, table (4.1).

	Pessimistic	Optimistic
2011	21.6	21.7
2012	25.0	25.1
2013	26.9	27.0
2014	28.1	26.0
2015	30.0	24.7
2016	29.0	23.2

Table 4.1: Economic forecast of the Spanish unemployment rate in percentage.
Source: Own performance from data available by $OECD$, SG and IMF.

Table 4.2 shows the collected results performed by the computation of the system expressed in volume of $HIPS$ practice. Therefore, the percentages of O and R increase over time what justifies the robustness of our model. In table 4.3 we show the per-

		Pessimistic	Optimistic
2011	**P**	11 254 967	11 254 967
	O	1 053 420	1 053 420
	R	221 772	221 772
2012	P	11 006 649	10 949 977
	O	1 309 401	1 366 072
	R	237 292	237 292
2013	P	10 767 713	10 652 051
	O	1 551 885	1 676 449
	R	256 294	257 103
2014	P	10 532 153	10 337 791
	O	1 784 101	1 984 672
	R	278 676	281 171
2015	P	10 300 813	10 036 209
	O	2 010 186	2 276 481
	R	304 319	309 535
2016	P	10 078 698	9 747 855
	O	2 225 405	2 551 746
	R	333 156	341 996

Table 4.2: Subpopulations forecasts in volume of $HIPS$ according to the simulated scenarios.

centage that the three levels of consumption represents each year for the period of study $[2011 - 2016]$.

		Pessimistic	Optimistic
2011	**P**	89.82%	89.82%
	O	8.40%	8.40%
	R	1.76%	1.76%
2012	P	87.67%	87.23%
	O	10.43%	10.88%
	R	1.89%	1.89%
2013	P	85.62%	84.64%
	O	12.34%	13.32%
	R	2.03%	2.04%
2014	P	83.62%	82.02%
	O	14.16%	15.74%
	R	2.21%	2.23%
2015	P	81.65%	79.51%
	O	15.93%	18.03%
	R	2.41%	2.45%
2016	P	79.75%	77.11%
	O	17.60%	20.18%
	R	2.63%	2.70%

Table 4.3: Subpopulations forecasts of $HIPS$ according to the simulated scenarios.

Figures 4.2, 4.3 and 4.4 show how the trend lines of subpopulations P, O and R for two economic scenarios optimistic and pessimistic. It has been observed that for P, it decreases while for O increases and R the two curves in almost coincide. The O subpopulation (pessimistic scenario) evolves from 8.40% in 2011 to 17.60% in 2016, however, at the optimistic scenario evolves in the interval $[8.40\%, 20.18\%]$; while the R subpopulation for pessimistic scenario increases from 1.76% in 2011 to 2.63% in 2016 but, for optimistic scenario evolves in the interval $[1.76\%, 2.70\%]$.

Figure 4.2: Consumption of rational-consumer (P) during the period [2011-2016] by economic scenario.
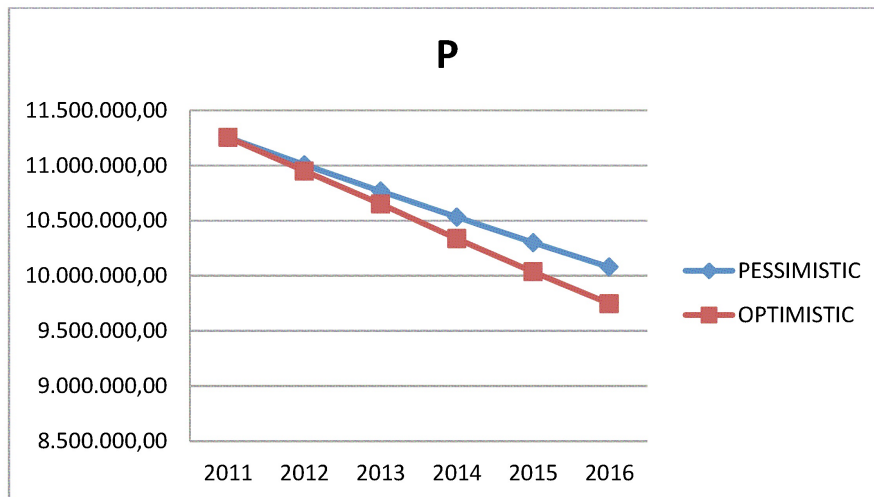
Source: Own performance.

Figure 4.3: Consumption of occasional-consumer (O) during the period [2011-2016] by economic scenario.
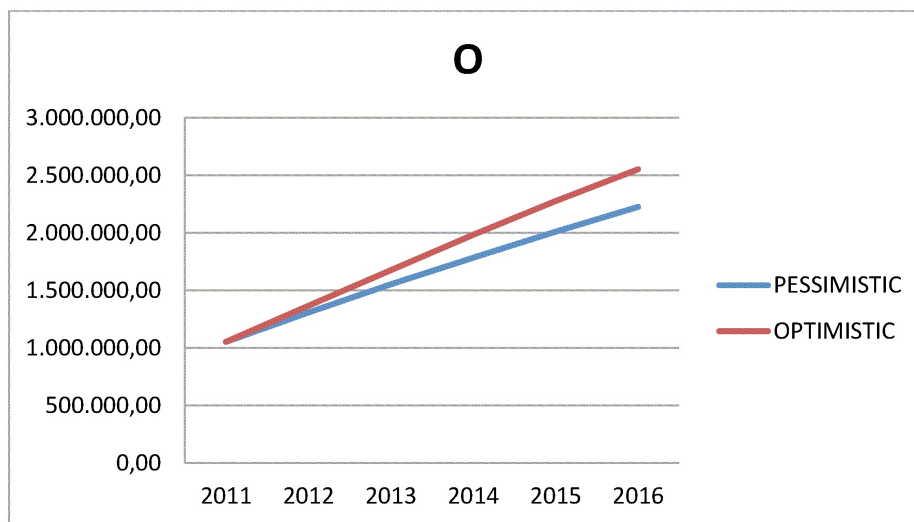
Source: Own performance.

Figure 4.4: Consumption of regular-consumer (R) during the period [2011-2016] by economic scenario.
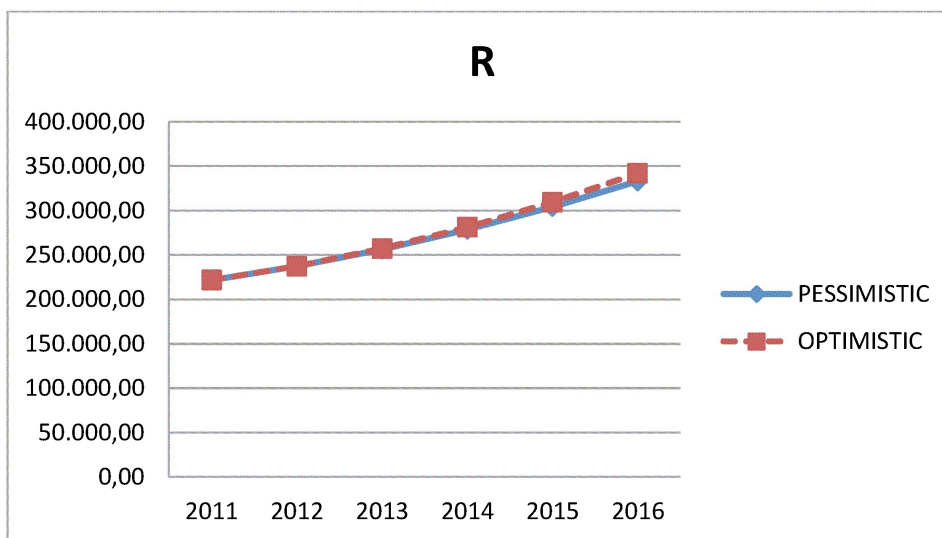
Source: Own performance.

4.4   Conclusions

$HIPS$ consumption increases for the period of time analyzed. The increase is performed by high-income level women, mainly R-consumers but, also by middle class women O-consumers.

The $HIPS$ procedures such as breast augmentation, breast reduction, liposuction an others become a popular good of consumption between rich and medium class Spanish women even with uncertainty about the improvement of the Spanish economy. Between the causes that incentive the $HIPS$ consumption are: professional success, body care, and the search for the emotional stability.

As a result of our study we can conclude that the practice of these procedures among occasional and regular-consumers may lead to develop body dysmorphic disorders (BDD). Public authorities should control the advertising/marketing through television and internet due to the relevance of the consumption of these goods from the medical point of view.

Chapter 5

Conclusions

This thesis deals with the study of two emergent sectors of economic activity: fitness practice and plastic surgery practice. The growth in demand experienced by both sectors in recent years is justified by the incremental body and image preoccupation.

Traditionally, body care has been a way to increase physical attractiveness (beauty treatments, diets, or physical exercise). However, the implementation of new technologies applied to body care during last 20 years has produced the blooming of both areas of economic activity, the result was the opening of fitness franchises, and also private surgery clinics.

The relevance of this thesis lies on the topics studied which are current issues affecting Spanish society as any other western society. Also, the novelty and relevance of this thesis consists in the studied issues (fitness and the practice of plastic surgery procedures) but also in the methods applied.

Due to the incipient emergence of those sectors, literature shows a gap in the study of the consumers' behavior as in the economic study of these sectors; also there is a lack of information related to its consumption, consumers' profile, and the measurement of its causes.

Thus, this thesis becomes the first study that forecasts the number of consumers of fitness centers and plastic surgery treatments measuring the impact that each factor has on the behavior of the individual.

However, the thesis is based on studying populations more than individuals. Individual human behavior may be erratic, but aggregated behavior is often quite predictable. The population model approach is also founded on the mimetic human behavior, human herding and social contagion. Epidemiological mathematical models have been employed during last years to describe the propagation of several social disorders such as the consumption of substances like alcohol, cannabis, tobacco, as well as the development of habits like compulsive shopping, workaholism, sex-addiction, eating disorders

In this thesis three epidemiological discrete mathematical models have been constructed to forecast (in the coming years in Spain) the practice of fitness by non-competitive bodybuilders (men), the practice of low-invasive plastic surgery procedures performed by women, and the practice of high-invasive plastic surgery procedures performed also by women.
In concrete, the first epidemiological mathematical model proposed in chapter 2 forecasts the fitness consumers for the next years $[2012 - 2015]$.

The second model showed in chapter 3 focuses on predicting the low-invasive consumption of plastic surgery practices ($LIPS$) during the period $[2012-2018]$. Finally, the third model centers on the high-invasive consumption of plastic surgery practices ($HIPS$) during the period $[2012 - 2016]$.

In each model, the population object of study is classified into categories depending on their level of activity/dependence measured by questionnaires developed for this purpose. Typically, there are two main ways to produce questionnaires to measure the level of consumption of a good or service: those questionnaires focused on the amount of activity performed or those focused on the psychological dependence of the consumer. Hybrid questionnaires combine both parameters to produce an appropriated questionnaire.

As it was previously said the lack of statistical data made necessarily the development of hybrid surveys that measure the level of activity of the consumers but also their psychological dependence. Again, the novelty of the thesis is shown by the construction of questionnaires that allow us to collect data.

Thus, the models construction started by studying the drivers that arise under the consumption of plastic surgery procedures and fitness practice such as psychological and emotional causes, but also economic and propagation ones.

The social contagion has been also used to explain the propagation of some socio-epidemics such as obesity or compulsive shopping. In contrast with previous studies of the epidemiological nature where the contagion effect is based on physical encounters among individuals', our study models the contagion effect as the influence of the media over the individuals' behavior (celebrities, advertising campaign and movies) reinforced by their families and friends.

As it was previously mentioned individuals become consumers of those products and services searching for a better appearance that helps them to improve their self-confidence levels, well-being status, the rebuilt of the personal life but also as a tool for achieving professional success or even as a mimetic behavior or human herding propagated by media and/or their micro-environment.

Also, it is important to point out that due to lack of official data about some variables such as the Spanish coupling rate, embracing those who are married but also those who are non-officially registered couples (or separations), the rate of Spanish coupling (or separations) is conservative estimated since we just considered the official data provided by the Spanish marriage rate (or Spanish divorce rate).

Following we detail the specific conclusions obtained from the study of the fitness consumption:

- The proposed model allows to forecast the volume of Spanish non-competitive body-builders at risk to be affected by MD in the period of study $[2012 - 2015]$.

- The development of the mathematical population model takes into account demographic, economic, emotional and behavioral factors and splits the target population into

three categories according to the amount of non-competitive body builder practice and their psychological dependence measured by the questionnaire TBV.

- By first time we introduce in the study of the MD the sociological influences such as the human herding and social propagation. The population model is set on the human behavior of herding and social propagation and the study of the dynamic transits between subpopulations along the period of study.

- Coefficients such as the social contagion effect are difficult to be accurately measured, that is why we developed a sensitivity analysis by studying the change of the results versus the variation of the social propagation parameter. Our results conclude that the proposed model is robust.

- One limitation of our study proceed from our hypotheses about the quantification of the influence of emotional status in the non-competitive body builder practice as well as the approximated age intervals when the male becomes economically self-sufficient.

- Simulating different scenarios of economic, the results of the model show the non-competitive bodybuilders at risk to develop MD are increasing next years. The results reveal that number of fitness users is especially higher between the young and unemployed men; thus, it means the economic factor plays a double opposite effect that can be briefed as follows:

    - When there are not jobs, the individual has more spare time to spend on the gym.

    - When the individual does not have a job the available income reduces, it does reduce his expenditure on spare activities such as the gym.

- The abuse of fitness practice is usually linked to the consumption of products such as energetic drinks, diet complements, and in the worst-case steroids what increases the risk of developing MD.

- Spanish Public Health Authorities should develop strategies to understand the causes that origin the propagation of MD and implement measures to prevent it such as campaigns to promote the healthy practice of sports, the promotion of group sports, the advertise of the danger of the abuse of gym practice and/or substances.

Then, about the plastic surgery consumption we can conclude:

- The proposed models for the $LIPS$ and $HIPS$ procedures are the first studies that forecast the $LIPS$ and $HIPS$ treatments while previous studies focused on the willingness to consume rather than forecasting the real consumption.

- The results obtained from the mathematical model focused on the $LIPS$ consumption show the level of activity of $LIPS$ slows down between Spanish middle class due to the hard economic crisis, however the consumption of these products shows a

growing trend explained by the high-income women who maintain their expenditure while middle class reduces it. Even when the volume of $LIPS$ treatments performed reduces over time, the subpopulations' rates suffer minor variations, the regular and over consumers slightly decrease while the dependent consumers increase.

- Whereas, in the second model focused on $HIPS$ consumption, we showed that the consumption is increased by high-income women, mainly R-consumers, but also by middle class women O-consumers.

- The $HIPS$ procedures become a popular good of consumption between rich and medium class Spanish women even with uncertainty about the improvement of the Spanish economy.

- After simulating different economic scenarios, we can conclude how the occasional consumers increase while the regular ones decrease over time, independently of the economic situation.

- The $HIPS$ procedures such as breast augmentation, breast reduction, liposuction an others become a popular good of consumption between rich and medium class Spanish women even with uncertainty about the improvement of the Spanish economy. Between the causes that incentive the $HIPS$ consumption are: professional success, body care, and the search for the emotional stability.

As final conclusions of the thesis it is relevant to point out the main advantages of the proposed models are the possibility to be applied to any other western country where data are available as well as to another period of study in which the hypotheses remain applicable.

The models allow the possibility of simulating artificial scenarios simply by changing the values of the parameters and computing the subpopulations with the model.

In addition, the model has the potential advantage that the period of study can be modified assuming a lost of accuracy due to the uncertainty of the economic future.

This thesis shows the rapid propagation of the consumption of body care services among men and women indicating the existence of a relationship between psychological, emotional, and economic factors that influence consumers' behavior. In addition, the abuse of those may lead individuals to develop body dysmorphic disorders (BDD) and dissatisfaction about their body image. Public authorities should control the advertising campaigning via marketing through the media and internet due to the relevance of the consumption of these goods from the medical point of view.

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Appendix A

ENCUESTA ANÓNIMA SOBRE LAS PRÁCTICAS SALUDABLES

La siguiente encuesta será utilizada para conocer los hábitos saludables de la población española. Su opinión es importante para esta finalidad y contribuirá a generar recomendaciones de salud pública.

Gracias, por contestar a las siguientes preguntas

1. Edad:...........................

2. Sexo: | Hombre | Mujer |

3. Actividad profesional:..................

4. ¿Prácticas algún otro deporte aparte del gimnasio?
Sí,
No.
A continuación, marque con un círculo la opción A, B o C que corresponda a su opinión:

1. Frecuencia de prácticas deportivas.
A. Frecuento el gimnasio 2 o 3 veces a la semana.
B. Voy todos los días al gimnasio.
C. Voy poco al gimnasio o no voy.

2. ¿Cómo ves tu apariencia física?
A. Fuerte y musculosa.
B. Delgada y poco musculosa.
C. Tengo el tamaño adecuado.

3. ¿Cómo ves tu tamaño muscular?
A. Me gusta.
B. Me gusta mucho.
C. No me gusta.

4. ¿Estás pensando en mejorar tu cuerpo?
A. Constantemente.
B. De vez en cuando.
C. Rara vez.

5. ¿Cómo te gusta vestir?
A. Con ropa holgada y suelta.
B. Con ropa ajustada.
C. Cualquiera.

6. Para aumentar mi masa muscular:
A. No modificaría mi dieta ni consumiría fármacos especiales.
B. Estoy dispuesto a cambiar mi dieta y/o consumir algún suplemento, (por ejemplo: proteínas, carnitina, complejos vitamínicos...?
C. Alguna vez he consumido algún producto especial.

7. ¿Te preocupa tu deficiencia muscular?
A. Alguna vez.
B. Nunca.
C. Constantemente.

8. Tu afición al gimnasio te ha causado algún problema con los demás (laborales, familiares, sentimentales...).
A. Nunca.
B. Frecuentemente.
C. Alguna vez.

9. Creo que los inconvenientes de llevar una dieta, o de practicar mucho en el gimnasio, o el uso de suplementos (batidos proteicos, carnitina, vitaminas, etc...):
A. Son necesarios.
B. Depende.
C. No, en absoluto.

10. ¿Cómo te sientes si por algún motivo imprevisto no puedes ir al gimnasio?
A. Me adapto.
B. No me importa.
C. Me enfado.

Appendix B

Questionnaire about the health practices of the population

This questionnaire is will be used to analyze the behavior of Spanish people about their healthy habits. Your opinion will be valuable source of information and it will contribute to develop public health recommendation.

Thank you for answering the following questions.

1. old:............................

2. Sex: | Male | Female |

3. professional Activities:....................

4. Do you practice any sports other than the Gym?
Yes,
No.
To continue, mark with circle the option A, B, C. Which correspond with your opinion?

1. The sports-practices frequently.
A. The Gym frequently 2 or 3 times per week.
B. I go to the Gym every day.
C. I go to the Gym few or i don't go.

2. How do you see your physical appearance?
A. Strong and muscular.
B. Skinny and slightly muscular.
C. I have sufficient size.

3. How do you see your muscle size?
A. I like.
B. I like it too much.
C. I don't like.

4. Are you thinking to improve your body?
A. Constantly.
B. Occasionally.
C. Rarely.

5. How would you like to adress?
A. With baggy clothing and loose.
B. With tight clothes.
C. Anyone.

6. To increase your muscle mass:
A. Not to change my diet or special consuming.
B. I am ready to change my diet and / or consume some supplements (eg. Protiens, carnitine, complex vitamin ..?
C. Sometime i consumed some special products.

7. Are you preoccupied with your muscle deficiency?
A. Sometime.
B. Never.
C. Constantly.

8. You like the fitness that caused any problem with others (work, family, sentimental.....).
A. Never.
B. Frequently.
C. Sometimes.

9. I think inconveniently to have diet, or to practice a lot in the Gym, or use the supplements ("protein" milk shakes, carnitine, vitamins, etc..):
A. Are necessary.
B. Depend.
C. Not, at all.

10. How would you feel if an unexpected reason(s) you can't go to Gym?
A. I adapt.
B. I don't import.
C. I get angry.

Appendix C

ENCUESTA SOBRE ESTÉTICA

La siguiente encuesta va a ser utilizada para conocer como la población española cuida su imagen. Su opinión será importante para esta finalidad y contribuirá a generar recomendaciones de salud pública.

CUESTIONES

A continuación, marque con un círculo la opción A, B, C etc. que corresponda a su opinión:

1. Estado civil.

A. Soltera.
B. Casada/en una relación.
C. Divorciada/Separada/Viuda.

2. Edad.

A. 16-20
B. 20- 30
C. 30-40
D. 40-50
E. 50-60
F. 60-70
G. 70 +.

3. ¿Tienes un trabajo remunerado?

A. Si.
B. No.

4. Tu nivel de ingresos es.

A. Bajo.
B. Medio.
C. Alto.

5. Nivel de estudios.

A. Primeros.
B. Secundarios.
C. Superiores.

6. ¿ Conoces a algún familiar o amig@ que haya tenido experiencias de cirugía plástica?

A. Si, ¿ Cuántos/as?.........
B. No.

7. ¿ Has tenido experiencias personales de cirugía estética?
A. Si, ¿ Cuantas veces?........
B. No.

8. Si contestaste SI a la pregunta anterior, ¿te aplicarías otro tratamiento si tuvieras posibilidades económicas?

A. Si.
B. No.

Appendix D

QUESTIONNAIRE ABOUT BODY IMAGE

This questionnaire is going to be used to analyze how Spanish population takes care of their image. Your opinion will be valuable source of information and it will contribute to develop public health recommendation.

Questions

To continue, mark with circle the option A, B, C etc. Which correspond your opinion?

1. Your marital status.

A. Single.
B. Married/Reletionship.
C. Divorced/Widowed.

2. Age.

A. 16-20
B. 20- 30
C. 30-40
D. 40-50
E. 50-60
F. 60-70
G. 70 +.

3. Do you have a paid activity?

A. Yes.
B. No.

4. Level of income.

A. Low.
B. Medium.
C. High.

5. Level of education .

A. Primary school.
B. High school.
C. University degree.

6. Do you know any relative or close friend who has had any aesthetic surgery procedures/treatment?

A. Yes, How many people?.......
B. No.

7. Have you had any experiences with aesthetic surgery?
A. Yes, How many times? ....
B. No.

8. If you answered YES to the previous questions, would you do any other aesthetic surgery, if you had economic resources?

A. Yes.
B. No.