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ARTICLE

Predicting Workaholism in Spain: a discrete mathematical model

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At the present time one of the most 'desirable' behavioral addictions that any person could develop is workaholism, a negative psychological state characterized by working excessively and compulsively. In our society, the successful person is who spends all time working. Moreover, a common pattern of company's management consists of stressing and putting pressure on their employees to achieve the maximum profit. This trend has increased with the economic crisis in Spain and over the world. As a consequence, the terms hard working and workaholism are easily confounded, but their effects on the companies are highly different in terms of productivity. This paper proposes a discrete mathematical model to forecast the development of workaholism in Spain in the next years. A questionnaire is used in order to measure and classify our sample in subpopulations by their level of addiction. Then, different economic scenarios are simulated. Finally, economic and social consequences of this addiction are studied and public health recommendations are suggested.

Keywords: workaholism; mathematical model; productivity; addiction; engagement; public health recommendations.

AMS Subject Classification: 91-XX; 92D25; 39Axx (AMS Subject Classification)

1. Introduction

Substance abuses and addictions have been intensely investigated by psychologists and psychiatrists due to their damaging effects on people's health. On contrast, other types of addictions described as non-conventional, have been barely studied despite their increasing repercussion. One of the addictions not produced by the consumption of psychoactive substances is workaholism, a syndrome characterized by a tendency to work excessively in a compulsive way [1]. Although, workaholism is not specifically defined in DSM-IV-R [2], has been studied by psychologists and psychiatrists since Oates defined the concept and its negative consequences in 1971 [3].

In western societies, work becomes a relevant manner of obtaining social support and reinforcement [4]; people are encouraged to pursue their job promotion increasing their working hours and avoiding dismissal. In particular, Spain has lost a total of 2.2 million jobs since the crisis began in late 2007 and also its unemployment rate reached the 23% of its workforce in 2011, the highest rate of the OECD

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countries. Also, the current unsettled macroeconomic environment suggests that joblessness will remain high in Spain over the next few years [5].

In this context, Spanish companies recruit and promote those employees capable to work intensely and commit to help their firms; they are known as 'work-engaged' employees [6]. However, organizational commitment can become a negative attitude since it might evolve into workaholism. Unlike engaged employees, workaholics do not enjoy doing things outside work, they even feel guilty when they are not working, and they work hard because of a strong, irresistible inner drive [1]. Workaholism is associated with negative consequences such as stress [7], psychosomatic symptoms [8], physical exhaustion [9], burnout [10], poor social relationships [11], family problems [12] and poor job performance [13]. Despite the theoretical of previous studies [14] clarifying the processes involved in workaholism, any of them forecasted the prevalence of this syndrome in the next few years.

A discrete mathematical model that allows us to predict the prevalence rate of workaholism in Spain. To build the model we consider economic and psychosocial factors that determine the dynamic behaviour of Spanish employees such as the Spanish economic context, the emotional impacts (separation, divorce [15]), and social contagion [16], [17]. Finally with the results obtained, prevention measures are suggested to implement public policies.

The paper is organized as follows: apart of section 1, section 2 presents the data and the mathematical model construction starting as a social epidemiological population model whose dynamic is expressed as an explicit linear quadratic difference system. Hypothesis of the model and matching coefficients approach are also considered in this section. Section 3 shows the results of the simulations under different forecoming economic scenarios and finally, the conclusions, and recommendations to promote public health are included in section 4 .

2. Mathematical model construction

2.1 Sources of information

The population of study is composed by individuals who are employed in Spain, embracing all occupational categories in the age interval [16, 69].

In order to analyze the level of addiction to work, we passed a validated questionnaire composed by two main scales: the short Spanish version of the DUWAS (Dutch Work Addiction Scale) [18] to assess the level of workaholism, and the short Spanish version of the UWES (Utrecht Work Engagement Scale) [19] to assess the work engagement status. These questionnaires let us measure both the number of working hours and also the psychosocial dependence of the individuals to their jobs.

Two samples were taken at two different dates, first one (S1) in May 2011 and second one (S2) in April 2012. The stratified sampling method based on the gender, age and employment status of the Spanish population [20] was applied. The sample in S1 included 553 employees whereas in S2 was composed of 613 ones.

2.2 Mathematical model and hypotheses

Three subpopulations are defined for the construction of the proposed model:

- Rational workers (N): those individuals who work 40 or less hours per week and obtain a score lower than 3.25 in the short Spanish version of the DUWAS [18].
- Overworkers (S): those individuals who work more than 40 hours per week and

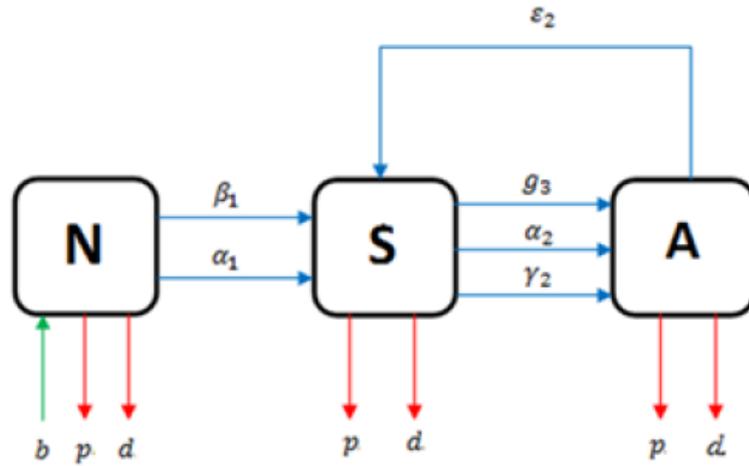


Figure 1. System dynamic.

obtain a score lower than 3.25 in the short Spanish version of the DUWAS.

- Workaholics (A): those individuals characterized by obtaining a score higher than 3.25 in the short Spanish version of the DUWAS.

Note that the engaged employees are a subset of S and N subpopulations. Then n_e is defined as the percentage of rational workers (N) who are also engaged workers, and s_e as the percentage of overworkers (S) that are engaged workers. The engaged overworkers (s_e) are those on risk to transit to the addicts' subpopulation. The dynamic of the model is depicted by figure 1. Therefore, the assumed hypotheses are specified below.

- The individuals come into the model as rational workers (N) if they enter the labor market for the first time or as N , S or A if they were unemployed and find a job.
- Whereas they can leave the model as a N , S , or A worker due to two causes: their dismissal or because of passing away.
- The individuals can only transit from one category or subpopulation to another. That is: $N \rightarrow S$, $S \rightarrow A$, $A \rightarrow S$.
- The causes of transit to higher levels of over-work are determined by economic, emotional conflicts and social contagion; thus those conflicting events that drive people to increase their work commitment, as a mechanism to escape conflicts in other areas of their lives [21]. These causes are explained as follows:
 - o The economic crisis leads to the companies to pressure their workers to increase their working hours and/or productivity [22] [23]. Those employees with renewable contracts, transit from N to S stressed under the possibility of losing their jobs, [24], what is defined as β_1 .
 - o The emotional shocks that individuals experience along their labor life such as divorce or relative's illness, might increase their desire to work longer hours [25] in an attempt to escape from their conflictive family atmosphere [26], the workplace reinforces their level of self-esteem. The N employee transits to S , and S to A , the parameters are defined as α_1 and α_2 , respectively.
 - o The "social contagion", is explained as the influence that addicts have on overworkers' behaviours [16]. In both, big and small organizations a social contagion is produced especially when the manager works an excessive number of hours [27] or a co-worker becomes promoted, inducing the rest of workers to work more hours. The social contagion estimates the transfer rate from

overworker (S) to workaholic (A), this rate is expressed as γ_2 . Note that the influence of addicts (A) over rational workers' behaviour is considered as trivial.

- Finally, the workaholic (A) can recover becoming an engaged over-worker. Once this point is reached, the workaholic (A) will move from an extrinsic motivation (security, success, etc.) to a basis of intrinsic motivation (leisure, sentimental relationships, etc.) and become an overworker (S) [22].

The variation of each subpopulation in the interval $[n, n + 1]$ is expressed as follows (n represents months):

$$\begin{aligned} N_{n+1} - N_n &= b(N_n + S_n + A_n) - dN_n - pN_n - \beta_1 N_n - \alpha_1 N_n, \\ S_{n+1} - S_n &= -dS_n - pS_n + \beta_1 N_n - g_3 S_n - \gamma_2 S_n A_n - \alpha_2 S_n + \epsilon_2 A_n + \alpha_1 N_n, \\ A_{n+1} - A_n &= -pA_n - dA_n + \alpha_2 S_n + \gamma_2 S_n A_n - \epsilon_2 A_n + g_3 S_n, \\ P_n &= N_n + S_n + A_n. \end{aligned}$$

Then, the parameters of the model were estimated:

- $b = 0.00047 = [0.01053 \times (1 - 0.464)]/12$. The rate of individuals who work for the first time; calculated as the Spanish birth rate in 2010 minus the Spanish youth unemployment rate in 2011, (46.4%) [20].
- $p = T_{n+1} - T_n$. People who become unemployed, and leave the model. T_n defined as the unemployment rate in the month n .
- $d = 0.002248/12 = 0.000187$. Average Spanish mortality rate of people between 16-69 years old [20] in 2010.
- $\alpha_1 = 0.8 \times n_{e(n)} \times 0.5855 \times 0.000225 = 0.00000325$. The emotional impact rate is estimated as the 80% of n_e (obtained from our samples as the average in S1 and S2, 3.1%) in the age interval [30, 50], (58.55%), who suffers an emotional conflict transits to the next subpopulation, $N \rightarrow S$, $S \rightarrow A$. (0.27% of Spanish population dissolves their marriage per year, estimated as the average rate from 2006 to 2010 [20], 0.0225% per month).
- $\beta_1 = \beta_a \times 1.96(T_{n+1} - T_n)$. The economic impact rate is the proportion of rational workers (N) concerned by their dismissal (β_a) who transit to over-workers (S). We estimated β_1 as almost twice (1.96; [28]) of the increase of the monthly unemployment rate multiplied by β_a , where β_a represents the proportion of concerned rational workers (N) who decide to increase their working hours, fitted by Nelder Mead algorithm [29]. Note that $\beta_1 = 0$ when $T_{n+1} < T_n$.
- $g_3 = (0.182 \times s_{e(n)})/12 = 0.015 \times s_{e(n)} = 0.002368$. Represents those S whose score is close to addiction (between 2.7 and 3) in the short Spanish version of the DUWAS (Utrecht Work Addiction Scale; [18]) and we assume they will transit to A in a year. We calculated $s_{e(n)} = 0.157905$, as the average for S1 and S2.
- $\alpha_2 = 0.8 \times s_{e(n)} \times 0.5855 \times 0.000225 = 0.000105 \times s_{e(n)} = 1.658 \times 10^{-5}$. As α_1 , this rate represents the transition due to emotional impacts. Note that ($s_{e(n)}$) (obtained from our samples as the mean in S1 and S2) is 15.79%.
- γ_2 . Social contagion parameter, fitted by Nelder Mead algorithm.
- $\epsilon_2 = 0.005/12 = 0.000416$. A rate of recovery from A to S is considered. We assume that 0.5% of A transit to S per year [22].

All parameters were estimated with the exception of the social contagion parameter γ_2 and the economic parameter β_a that were adjusted using the samples in S1 and S2 and implementing the Nelder-Mead algorithm as in [30],[31], applying the Mathematica software.

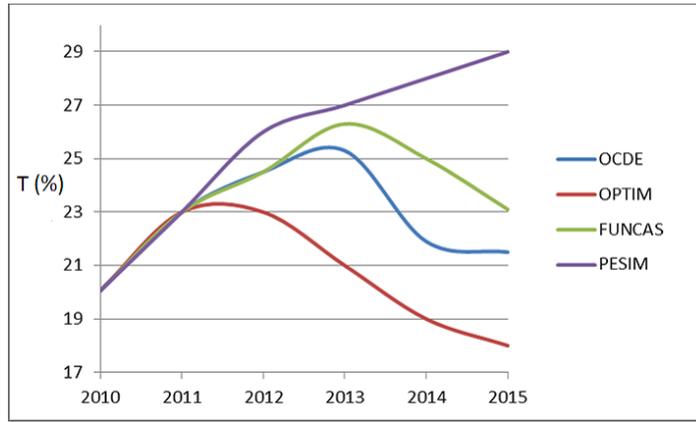


Figure 2. Economic scenarios considered.

2.3 Economic scenarios

We consider diverse economic scenarios based on OECD and FUNCAS data until 2013 while for the years 2014 and 2015 we forecast the Spanish unemployment rate. Also we simulated the rate of unemployment under two more scenarios an optimistic and pessimistic one.

- OECD: a scenario showing an increasing unemployment rate until 2013 and a subsequent sharp decline between 2014 and 2015, reaching levels below those of 2011 for 2015.
- OPTIMISTIC: positive development of the economic situation; the unemployment rate decreases the unemployment rate from 2013 to pre-2010 levels.
- FUNCAS: similar to OECD scenario, reaching higher unemployment rates for 2013 and a slow economic recovery from 2014.
- PESSIMISTIC: negative evolution of the economic situation, with an increase of the unemployment rate from 2012.

Year	OECD	Optimist	FUNCAS	Pessimist
2010	0.2006	0.2006	0.2006	0.2006
2011	0.23	0.23	0.23	0.23
2012	0.245	0.23	0.245	0.26
2013	0.253	0.21	0.263	0.27
2014	0.219	0.19	0.25	0.28
2015	0.215	0.18	0.231	0.29

Table 1. Economic scenarios.

For the simulation it was assumed that the percentage of marriage dissolutions changes over time according to the economy [15]. Consequently it was considered for the time horizon of 2013-2015 a monthly marriage dissolution rate obtained as the average of the three scenarios proposed in this study, being 0.000419, 0.000453 and 0.000505, respectively.

3. Simulations results

The two parameters adjusted, γ_2 and β_a , take the following values: $\gamma_2 = 1.06097 \times 10^{-6}$ and $\beta_a = 6.077 \times 10^{-20}$.

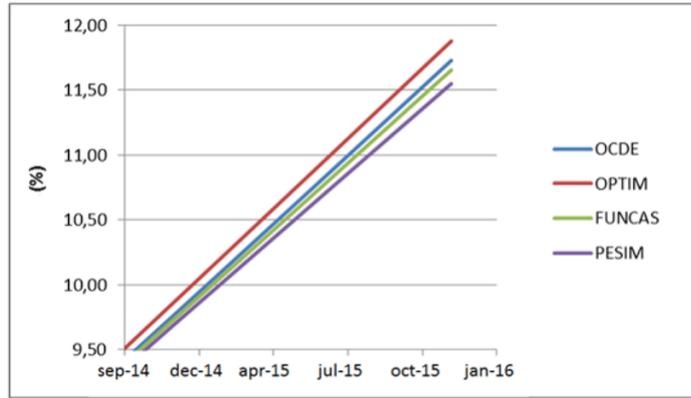


Figure 3. Evolution of the percentage of addicts (Sep-14 to Dec-14).

The table 2 shows the results from May 2011 (S1) until December 2015, and figure A shows the results from September 2014 to December 2015. As conclusion, the prevalence rate of workaholism in Spain increases for the four economic scenarios considered.

Year	OECD	Optimist	FUNCAS	Pessimist
May 2011	4.00	4.00	4.00	4.00
April- 2012	4.629	4.629	4.629	4.629
Dec - 2012	6.139	6.145	6.139	6.134
Dec - 2013	7.925	7.965	7.920	7.899
Dec - 2014	9.808	9.909	9.775	9.732
Dec - 2015	11.728	11.877	11.654	11.549

Table 2. Development of the workaholic rate from 2011 to 2015.

Let us note that in the course of four years the prevalence of workaholism has been almost tripled, from 4% in July 2011 to approximately 11.5% in December 2015. Furthermore, differences between scenarios highlight that the percentage of workaholics in the Spanish population is higher for the optimistic economic scenario.

Also, note that addicts' subpopulation increases over time, however over-workers' subpopulation suffer an initial increase (from 15.33% in May 2011 to 18.87% in April 2012) followed by a decrease reaching approximately the prevalence level of A in Dec-2015 (11.13% for the pessimist scenario to 11.45% for the optimist one), due to the strong effect of the social contagion γ_2 . In absolute terms the number of over-workers evolved from 2,759,400 to 2,032,200 and the number of addicts from 720,000 to 2,108,340 from 2011 to 2015 respectively.

Finally, we analyzed the sensitivity of the workaholics' percentage to the fluctuation of the social contagion parameter γ_2 and β_a between the interval $[1/2\gamma_2, 3/2\gamma_2]$ and $[1/2\beta_a, 3/2\beta_a]$. 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, optimistic, FUNCAS, pessimistic). Since there are two social contagion parameters γ_2 and β_a with different fitting values, we will simulate each parameter γ_2 , β_a considering that the other one remains constant.

The sensitivity of the workaholics' percentage to the oscillation of β_a , was almost null, since the subpopulation of workaholics practically remain constant for all possible values of this parameter.

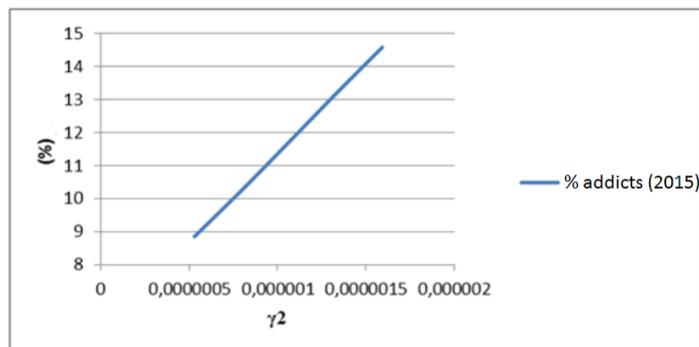


Figure 4. Evolution of the percentage of addicts in 2015 depending on the value of γ_2 .

However for γ_2 , results are shown in figure 4. Note that for a fluctuation of the social contagion parameter γ_2 between the interval $[1/2\gamma_2, 3/2\gamma_2]$ the prevalence rate of workaholism fluctuates between the interval $[8.84, 14.58]$.

4. Conclusions and recommendations

This paper proposes a difference equations model to predict the trend of the proportion of workaholics in Spain under different economic situations.

Note that for all economic scenarios the percentage of workaholics increases from 4.6% in 2012 to around 11.5% in December 2015, which is an undesirable prediction if one takes into account the negative consequences associated with workaholism.

Therefore, based on the results obtained in our study, it would be convenient to propose measures in order to prevent the social contagion of workaholism. The organization's culture should encourage the quality of the daily performance, intensifying the commitment of employees based on the ethical acceptance of their responsibilities, without adding labor stress to the workers, what would reduce the number of temporary leaves of absence and its associated costs.

Related to the social contagion from the worker's perspective we recommend to promote a healthy competitiveness in the organization avoiding the imitation of addicts or over-workers bad practices.

Also, any emotional impact affecting the worker can be minimized when the individuals enrich their free time with activities, such as practicing sports but also by promoting their personal or cultural values.

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