POPULATION PROJECTIONS: A TOOL FOR THE (RE)DEFINITION OF THE PORTUGUESE HIGHER EDUCATION SYSTEM

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Summary

Population projections can be used as a tool to provide information on possible scenarios of future population and, namely, to support decision-making processes in diverse socio-economic areas, such as, higher education institutional network planning, both in public and private sectors. In a country like Portugal, nowadays affected by a severe economical and financial crisis, with a young population characterized by low levels of education and qualification is fundamental to use population projections as a basis for higher education planning.

The main goal of this paper is to evaluate the possible changes in the younger population size in the coming years as a tool to (re)think and (re)design geographically the higher education institutional network in Portugal. Our findings will provide a range of reliable forecasts to support a more rational political decision contributing to an efficient and effective planning in what concerns higher education requirements adjusted to the evolution of future population.

Keywords: Population Projections, Higher Education Institutional Network, time series analysis.

1. Introduction

Population projections can be used as a tool to provide information on possible scenarios of future dimension, age and sex composition of population, and therefore to support decision-making processes in diverse socio-economic areas, such as higher education institutional network planning, namely, in a context of a young population still characterized by very low levels of education.

The main goal of this paper is to evaluate the possible changes in younger population size in the coming years, based on the results of population projections, by age and sex, using the cohort-component method. This main goal is part of an extended research project, with the aim of a (re)definition of the Network for Higher Education in Portugal. The projection of the population in the near future that will be "at risk" of entering that grade level is crucial. We will focus our scope on young people aged between 18 and 30, considering sex and age distribution, in the time horizon of the next 25 years.

In this paper, we will test the application of different methodologies to predict fertility and mortality, the main components responsible for the evolution trend of young people, as potential candidates to higher education at the considered time interval.

Despite the importance of the migration component, once both levels of emigration and immigration are more significant at young adult ages, at which may affect the prediction of the number of young people under the usual age of accessing higher education, and simultaneously influence the number of births (however, in this case, the biggest effect will be noted only18 years later), we do not include the migration component in this study, namely due to its high volatility and the high level of difficulty to predict it in the long term.

2. Brief overview of Higher Education in Portugal

Over the past 40 years, the development of the Higher Education Network in Portugal has proved to be a major factor for the country development. One of the key questions regarding the future of higher education network is related to the fact that the number of young people in Portugal have declined dramatically in recent years. Does the entry of young adult population in this level of education will continue to increase, as seen in the first 30 years of democracy, i.e., since the beginning of the 80's in the past century? Or will simply follow the same downward trend observed in recent years?

The Higher Education System is divided into two subsystems: public and private; and organized according an "university subsystem" (that grants a more solid scientific preparation) or a "polytechnic subsystem" (that provides a more technical training and more profession-oriented).

A preliminary analysis of students enrolled in higher education in Portugal allows to highlight some issues. In the last 12 years, students enrolled in higher education are mostly women, despite the decrease of the differences between sexes in the recent past. The public system is the predominant one, whether at the level of university or polytechnic. This can be explained by two reasons: 1) the high cost of private education; and, 2) the high quality of public education. It is also noteworthy the increase in the number of students in the public sector compared with the decrease in the private one, namely since 2008/2009. Such disparity can be explained by the greater difficulties faced by families to support educational costs, mostly due to the current economic crises.

In watt concerns to university or polytechnic subsystems, the university subsystem absorbs most of the students in Higher Education in Portugal, and the difference between the two subsystems remains approximately the same throughout the past 12 years. About the selected scientific areas, Agriculture remains the less attractive area to higher education students. Social Sciences, Business and Law are the areas that attract more students. The major decrease on the number of enrolled students by scientific area was in the case of Education, while a marked increase was observed in the case of Health and Social Protection. Of all the areas analyzed,

these two show an obvious change in the number of enrolled students between 2000 and 2012, whereas in the remaining six areas[1] the number remains constant.

After April 25th 1974 there has been a radical change in the attitude towards education in Portugal and changes in the level of education were overwhelming. In 1986/1987, the compulsory education was raised to nine years of schooling and in 2005/2006 to 12. In 2010/2011, took effect, the requirement of one year of pre-primary schooling covering all children 5 years of age. Prior to April 25th 1974 the number of students in higher education were less than 30 thousand, while in the academic year 2011/2012 this number was around 400,000 (DGEEC[2]). However, and despite the numerous efforts made since the democratic revolution in April 1974, Portugal still has poor educational indicators, particularly when compared with other European countries.

Although the Bologna Process, implemented in 2006/2007, has allowed another increase in the number of students enrolled in higher education, mainly due to restructuring the different courses with the consequent decrease in the number of years required to obtain a degree, therefore causing smaller financial stress of families, the rate of enrolment in Portugal remained very low, compared to the majority of the European Union.

In recent years the rate of enrolment in Portugal has risen steadily, reaching values around 20% for young people aged between 18 and 29, already quite close to the 22% (2013) of the EU average (27 countries). However, this proportion is still distant from countries such as Finland, which has an enrolment rate at the same age group of 26% (Eurostat).

So, a projection of the number of individuals enrolled in higher education in the coming years is critical for a redefinition of the higher education network.

Will the increase in enrolment in higher education in Portugal offset the sharp decline expected for the younger resident population? Or, conversely, the population decrease will cause a decrease in the number of young people able to apply to higher education? The number of places offered by the Portuguese higher education network in recent years is the most appropriate considering the evolution of the demand?

3. Data and methods

3.1 Population Projection Methodology

Deterministic projections are frequently performed using different scenarios to deal with uncertainty. More recently, probabilistic projections of population have been developed with increasingly interest namely considering that they allow the estimation of a confidence interval associated with each outcome (Bongaarts & Bulatao, 2000). The uncertainty in the results come not from the formal model but from the uncertainty of the future evolution of components, being frequently the use of different scenarios or variants as a way of dealing with uncertainty.

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[1] The six scientific areas are: "Agriculture", "Arts and Humanities, Education", "Engineering, Manufacturing Industries and Construction", "Health and Social Protection", "Science, Mathematics and Computing", "Social Sciences, Business and Law, Services".

[2] Direcção-Geral de Estatísticas da Educação e Ciência, Portugal

An alternative is to explicitly take into account the uncertainty of the fertility, mortality and migration trends, and derive the probability distributions for the resulting size and age structure of the population projected (O'Neill, Balk, Brickman, & Ezra, 2001).

Thus, the complementary application of the most useful aspects of different methodologies, combining the scenario approach with probabilistic forecasts seems to be the most productive attitude (Goldstein, 2007; Sanderson et al, 2004).

The population projections have been calculated using the cohort-component method, were the populations are successively update according to the assumptions about future levels of the components and the natural ageing, in each scenario, from 2011 to 2035 (2010 is the base year). The formulation of hypotheses for future developments of components (fertility, mortality and migration) is based on the observation, analysis and modelling of past trends of each of the components and expert opinion and do not incorporated any exogenous variables. The alternative hypotheses are intended to illustrate a range of possible future results. The complexity of migration flows, especially regarding its volatility and the difficulties in addressing new forms of population mobility, supported the decision of include only a null migration assumption on this exercise.

The combination of alternative assumptions about the future evolution of mortality and fertility allows designing scenarios and we have chose the following three combinations of hypotheses: (a) *Optimistic* (high fertility and low mortality); (b) *Central* (medium fertility and medium mortality); (c) *Pessimistic* (low fertility and high mortality).

3.2 Fertility

We have analyzed the evolution of fertility, based on historical fertility data from 1981 to 2009, available at the Human Fertility Database.

In the fertility component we first establish the assumptions of possible evolution, in terms of expected developments in total fertility rate (TFR) and mean age at childbearing (MAC), based on the analysis of the recent trends in Portugal. Three assumptions are defined for the TFR: (f1) the maintenance of a very low fertility rate throughout the projection period, assuming a value of 1.3 children per woman, in 2035 – hypothesis designated by *low fertility*; (f2) the recovery of fertility levels in order to equal, in the end of the period, the value currently recorded nowadays in the European Union, reaching 1.6, by 2035 – hypothesis called *high fertility*; and, (f3) an intermediate scenario that envisages a less significant increase in fertility, reaching a value of 1.45 children per woman by 2035 – the *central fertility* hypothesis. The mean age at childbearing will remain around 30 years on average, decreasing slightly in the most optimistic scenario and prolonging the delay in the worst case.

For the estimation of the fertility rates by age, we have applied the model proposed by Schmertmann (2003 and 2005). Following this author, we model specific fertility rates by age proceeding thereafter to a linear interpolation between the projected values and the estimates for the base year (2010). The model characterize the profile of the specific fertility rates by age f_x, in terms of three axes (ages) that synthesize certain features observed in fertility behaviour. These three areas correspond in particular to the younger age at which record births (α), the age at which

the specific fertility rates reaches the maximum value (*P*), and the younger age after which fertility decreases 50 % of its maximum value (*H*). An additional parameter (R) is also used to obtain the level of fertility.
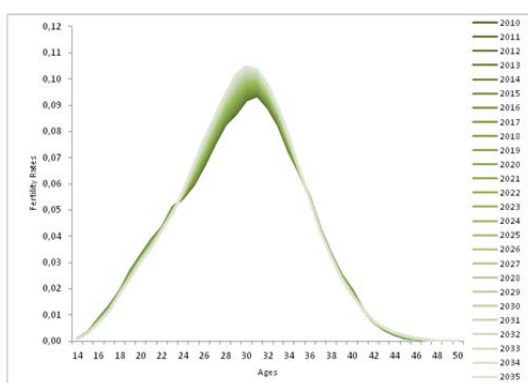
In formal terms, the exchange between the ages and an upper age limit are modelled by splines.

$$f(x) = R\phi(x) \tag{1}$$

$$\phi(x) = \begin{cases} \sum_{k=0}^{4} \theta_k \left(x - t_k\right)_+^2, & \alpha \le x \le \beta \\ 0, & x \notin [\alpha, \beta] \end{cases} \tag{2}$$

The distribution of fertility rates by age, over the next 25 years, according to the results for the scenario 2, may be represented as shown in Figure 1.

Figure 1 – Age specific fertility rates, Portugal, 2010-2035

Age specific fertility rates tend to increase slightly between 24 and 35 years of age, particularly between 28 and 32 years-old, but we do not anticipate a significant recovery of births postponed to ages above 37 years.

However, the gradual decline in fertility observed in Portugal in recent decades conditioned inexorably the size of the generations that, either currently or in the coming decades, will reach the age to start a family and have children. Thus, even under a scenario of recovery of fertility without constraints (eventually caused by foreseeable emigration flows), the number of births in the future is likely to be lower for the simple fact that we have, year after year, fewer women at childbearing ages.

The estimation of the births in this projection exercise clearly shows that the consequences of fertility decline registered in our recent past will be reflected inevitably in the future; it is not possible to reverse its effects in the timeline of the coming decades.

3.3. Mortality

We have analyzed and modelled the evolution of mortality, based on historical mortality data from 1981 to 2009, separately for both sexes, using data from the Human Mortality Database.

To project mortality we have used the most widely model in probabilistic forecasting of mortality, the Lee-Carter model (Raftery *et al*. 2013). It is an extrapolative model that projects into the future the trends of the historical data, according to the age patterns of mortality. As with all models, there are advantages and disadvantages associated with the method. However, from the initial article (1992) the Lee-Carter model has been the subject of study and application by different investigators, in different countries, namely Lee & Nault (Canada, 1993), Lee & Rofman (Chile, 1994), Wilmoth (Japan, 1996), Figoli (Brazil, 1998), Coelho (Portugal, 2001), Booth, Smith & Maindonald (Australia, 2002), Tuljapurkar, Li & Boe (G7, 2000).

The main advantage highlighted by several authors is how the model combines a demographic model and a parsimonious time series model, thus obtaining intervals for probabilistic projections. The possibility to incorporate into the model relatively long historical data series, also the fact that allow mortality rates progressively decrease exponentially over time, not being necessary to set an upper arbitrary limit with respect to the life expectancy, are clearly considered advantages.

With regard to the disadvantages must be noted that being a model extrapolative it shares all the problems of similar models. The past structure and trends used in the model may not occur in the future, there may be profound changes at the structural, demographic or social levels that the model will not be able to consider, such as, possible advances in medicine, profound changes in the socio-economic context, lifestyle transformations or the appearance of new diseases that radically alter the past trend.

The Lee-Carter methodology is a bilinear model in the variables x (age) and t (calendar year). The model is defined as:

$$\ln(m_{x,t}) = a_x + b_x k_t + \varepsilon_{x,t} \tag{3}$$

Where $m_{x,t}$ is the observed central death rate at age x in year t; a_x is a set age-specific constants describing the general pattern of mortality by age, i.e. describes the average age-specific pattern of mortality; k_t is a time-trend index of general mortality level, i.e., describes temporal trends in the level of mortality; b_x is a set of age-specific constants describing the relative speed of change at each age, is a pattern of deviations from the age of profile as the k_t varies; $\varepsilon_{x,t}$ is the residue at age x and year t, the random error with zero mean and variance σ^2.

The model allows us to obtain the values projected till 2035. Three assumptions are defined for the mortality component: (m1) defined by the central values of the model – *central mortality*; (m2) identified by the upper limit of the confidence interval of 90% calculated for mortality rates at each age – *high mortality*; and, (m3) delineated by the lower limit of the confidence interval of 90% calculated for mortality rates at each age – *low mortality*. The central values of the mortality rates for the Portuguese population are represented in Figures 2 and 3.

The trend shows a reduction in the rates at all ages, in particular as regards the younger ages, which mean that a greater number of young people will survive till

the older ages. Note that the expected gains in terms of reduced mortality in males will be substantial, maintaining however some comparatively higher values, for example, in the ages between 15 and 24 years old, associated with a history of high mortality mainly due to road traffic accidents. In the case of females, the decline in mortality rates will also increase, although it is noteworthy that the starting levels are much lower compared to those recorded by males, at all ages.

Figure 2 – Mortality rates, male population, aged from 0 to 35, Portugal, 2010-2035
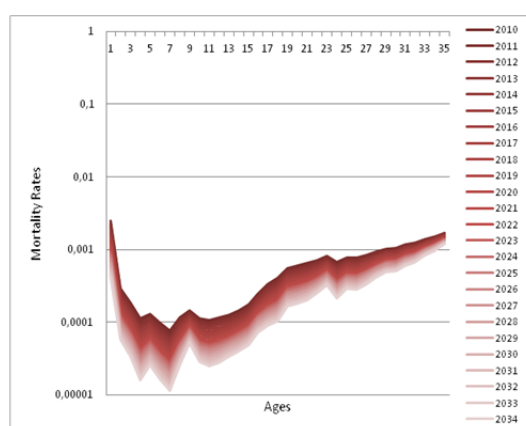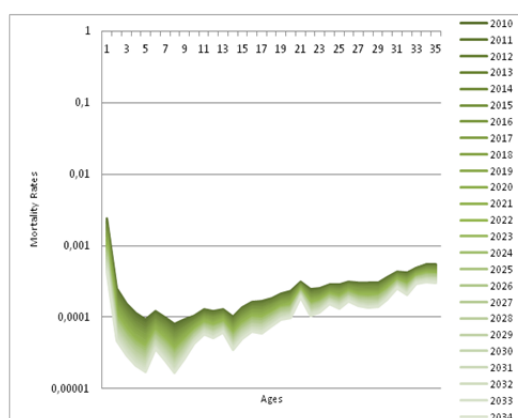

Figure 3 – Mortality rates, female population, aged from 0 to 35, Portugal, 2010-2035

3.4 Enrolment Rates Scenarios

One of the goals of this study is to estimate the behaviour of students enrolment in higher education over the coming years. In order to do this forecast we used the values of the population initially projected building up several scenarios for forecasting enrolment rates, based on: (i) a linear evolution of the enrolment rates registered in the past 12 years; (ii) a logarithmic evolution; (iii) an average growth rate recorded in the same period of time, the last 12 years; and (iv) the assumption of an identical evolution to the enrolment rates observed in EU27.

4. Results

4.1 Population projections

In Portugal, the higher education institutions have as prime candidates young individuals aged between 18 and 24, being the age of 18 the one with the largest number of applicants. Therefore, we considered this target population on our study. However, given that we still consider a margin of recruitment between ages 18 and 23, as well as in ages above 23 (due to the potential number of students attracted by after working courses), we analyzed not only individuals with the modal age 18, but also the people in the age groups between 18 and 24 and between 18 and 30.

With time the number of young people tends to decrease at all ages. However, depending on the initial population for each age or on the evolution of the corresponding probability of death, the variation has a greater or lesser extent; the variation in the number of births over past time may also be the cause of changes (see Table 1).

Table 1 – Total population – central scenario, 18 to 30 years old, Portugal, 2010-2035

| Age/Year	2010	2015	2020	2025	2030	2035
18	117131	107655	111397	105017	99470	89480
19	118450	108517	109278	108858	101131	91503
20	118573	106958	112470	108416	98847	93560
21	120226	110466	106628	111446	103989	95597
22	121072	113096	105960	113018	101852	97552
23	125624	116872	107462	111234	104892	99373
24	129238	118176	108312	109108	108720	101025
25	138346	118288	106746	112287	108270	98737
26	143429	119929	110240	106447	111289	103868
27	150230	120762	112855	105772	112851	101727
28	153051	125285	116608	107258	111057	104751
29	157705	128866	117888	108088	108917	108559
30	157967	137918	117975	106505	112069	108091

Considering the results of the three scenarios, the difference between the projected population values is almost nonexistent until 2028, due to the reduced effect of differences in mortality on population structure in young ages, in particular between 18 and 30 years old. After 2028 and until the end of the projection period, the differences increase among the different scenarios, mostly due to the impact of changes in fertility. Projected values of the population aged 18 years reflect, mainly, the past fertility trend in Portugal. Notice the values slightly higher than expected for the calendar years 2018 to 2021 as a result of the increased fertility occurred in 2000, as well as relatively high fertility rates until 2003.

The general declining trend of individuals aged 18 becomes more evident from 2028 onwards, when the evolution of future fertility is crucial in calculating the size of the projected population. In fact, the population aged 18 in the years preced-

ing 2028 results simply from the expected survival of births already occurred by the year 2010.

Between 2010 and 2035, it is likely that the size of the population aged 18 will decline around 23.6%, considering the so called central scenario, 21.9% in the optimistic scenario and 25.8% in the pessimist scenario (Figure 4).

Figure 4 – Population 18 year old, central, optimistic and pessimistic scenarios
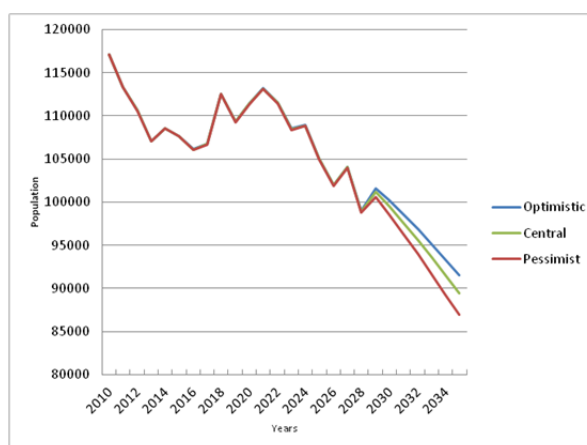

In what concerns the 18-24 age group, the downward trend remains (Figure 5). However, we can expect a slight increase in the population of this age group between 2020 and 2026, as an effect of a slight increase in fertility in Portugal between 1996 and 2002. In any of the scenarios the population of this age group declines from about 20.4% to 22.8%, for the optimistic or pessimistic scenario and 21.4% on the central scenario.

Figure 5 – Population 18-24 age groups, central, optimistic and pessimistic scenarios
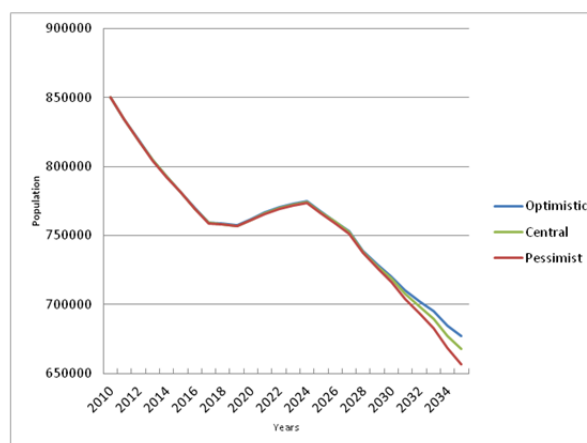
For the wider group, composed of young people aged 18 to 30 years, the decline is also quite visible (Figure 6), with a reduction of more than 25% whatever the scenario (-26.1%, central scenario; -25.5%, optimistic scenario; -26.9%, pessimistic scenario).

Figure 6 – Population 18-30 age groups, central, optimistic and pessimistic scenarios
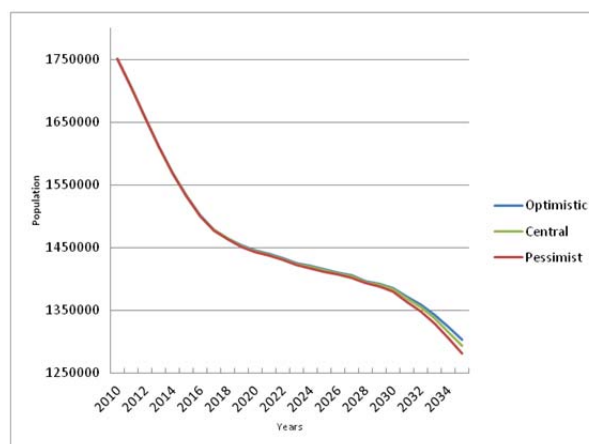
4.2 Enrolment students

In overall, following a linear trend of the enrolment rates, those enrolled in higher education in Portugal may increase to about 460 thousands by 2035; projecting an increase of more than 13 thousands students at the age of 18 years old until 2035 (i.e., an increase of about 40%).

According to a logarithmic evolution of enrolment there's a complete reverse of what was projected in the previous approach for the number of enrolled students in the higher education network. In this case, the increase of enrolment rates will be not large enough to counterbalance the decline in the projected population. Globally it would be noted a decrease around 10% of enrolled students till 2035, which represents approximately 34.000 students.

Enrolment rates will increase dramatically under the average growth rate scenario. The individuals in the 18 year old group will reach an enrolment rate of around 60% at the end of the period. According to this scenario, the total of enrolled students increased about 25%, attaining above 510.000 students.

In the scenario using the average growth rate in Europe, we selected several European countries. Despite the profound differences among them, we assume the European Union (27) growth rates. In this case, the group of 18 years old, will increase of about 1500 students in the period in analysis, offsetting the estimated decline in the young resident population. However, it is the age group of 18 to 29 years old which may register the largest increase in the number of students, increasing about 20%.

5. Conclusions

The first conclusion to be drawn of the different results is that the number of young people in Portugal will decrease significantly in the next 25 years. Thus, the young population, base of student's recruitment will be reduced proportionately and the demand of higher education in Portugal will be strongly influenced by this trend.

On the one hand, the demand for higher education in Portugal tends to decrease significantly in the years between 2010 and 2035, based on an expected decline of young population between 20-25% of the residents at the beginning of the current decade. But, on the other, considering the recent European trends, the enrolment rates in Portugal have the possibility to grew more over the next years.

Even considering impact factors with an opposite effect, such as: (1) possible changes in social policies and incentives to attract students for higher education specific courses; (2) a broadening of the recruitment base, despite the reduction in the size of the youth population, due to the extension of compulsory education to 12 years and a possible rise on the secondary graduation rates that may cause an increase in the proportion of applicants to higher education, (3) a greater propensity of young people for chose universities and polytechnics in order to acquire a higher education; we can conclude that the demand for higher education in Portugal tend to decrease significantly in the years between 2010 and 2035, based on an expected loss of young population, between 1/5 and more than a quarter of the population existing at the beginning of the current decade.

Further, we also believe that with a future change to (again) positive net migration would not be possible to reverse this trend of decreasing young population.

Moreover, there will be other factors that may act to decrease the absolute number of potential candidates, such as: (1) during periods of economic crisis the families decisions may be constrained and forced to restrict the access, in the case of the most economically disadvantaged candidates; (2) highly concentrated supply of courses (and institutions) may discourage applications from young people belonging to the lower income classes who need to move from one region to another; (3) the emigration currently registered in Portugal may become responsible for an even greater young ages depopulation.

In general, considering all factors, it appears that young people who most likely would have to apply to higher education in Portugal tend to decrease considerably in the coming years.

In fact, 3 out of 4 scenarios, forecast an increase on the number of enrolled students, even with a dramatic aging in the base of the age structure.

Based on our results the supply of Higher Education should be re-evaluated and re-organized to better suit the demand in Portugal.

We believe that the conclusions which may be drawn on the basis of this exercise show that demographic projections are a fundamental tool for the process of resetting the network of higher education in Portugal, particularly when major changes are foreseen either in the size of the base of recruitment, either in entry strategies, and also the reorganization of the training supply.

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