Artigo submetido a 2 de Dezembro de 2019; versão final aceite a 10 de Fevereiro de 2020
Paper submitted on December 2, 2019; final version acceptet on February, 2020

Demografia e Economia: Um Modelo Regional Integrado de Estimação da População Portuguesa

Demography And Economy: A Regional Integrated Model For Estimating The Portuguese Population

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Abstract/ Resumo

Population decline is one of the most demanding phenomena in recent decades in various European regions. Moreover, even in regions with a positive migratory balance, a negative demographic dynamic persists, dominated by an ageing population.

O declínio populacional é um dos fenómenos mais desafiantes nas últimas décadas em várias regiões da Europa. Mesmo em regiões com saldos migratórios positivos, persiste uma dinâmica demográfica negativa dominada pelo envelhecimento da população. Como tal, o tema

The model referred to in this paper was initially developed by the project DEMOSPIN (PTDC/CS-DEM/100530/2008) and is presently being developing in the project and P-RIDE [POCI / (POCI-01-0145-FEDER-016868] (economic component), SPLACH [Spatial PLAnning for Change (POCI-01-145- FEDER-1643)] (demographic component) and DRIVIT-UP (POCI-01-0145-FEDER-031905) (empirical application). All of these projects were funded by the Portuguese Foundation for Science and Technology. This work has been also part financially supported by the Research Unit on Governance, Competitiveness and Public Policy - GOVCOPP (project POCI-01-0145-FEDER-008540), funded by FEDER funds through COMPETE2020.

As such, demographic ageing and the role of migrations have become a widely debated research and policy topic.
Demographic change stands both as a cause and a consequence of social, economic and environmental dynamics. Therefore, economics and demography interact, reinforcing each other in circles of cumulative causation and, thus, regional policies to deal with such dynamics must be addressed and models able to simulate this interactive process are required.
An integrated model was developed with the aim of answering this challenge, linking changes in the match between labour demand and supply across changes in net migration by age group and sex. The model was applied to the regions of Portugal, a country that presents contrasting regional features, both in demographic and economic dimensions. The results demonstrate the demographic urgency and point to the importance of migratory balance to counteract the population decline of most Portuguese regions. Moreover, the paper emphasises the strong relationship between labour market and migration, advocating for integrated policies which jointly address economic and demographic dynamics.

Keywords: Demographic estimations and projections, Input-Output model, Public Policy, Regional development

JEL Code: J11, J18, R58, R15

do envelhecimento da população, e o papel determinantes das migrações, tornou-se uma área de investigação e de política regional amplamente debatida.
As alterações demográficas são ao mesmo tempo uma causa e uma consequência da dinâmica social, económica e ambiental. A economia e a demografia interagem, reforçando-se em círculos de causalidade cumulativa e, portanto, políticas regionais para lidar com essa dinâmica devem ser implementadas e modelos capazes de simular esse processo interativo são necessários.
Com o objetivo de responder a esse desafio, desenvolveu-se um modelo integrado que liga as mudanças do equilíbrio entre a procura e oferta de emprego, a nível regional, à migração líquida por faixa etária e sexo. O modelo foi aplicado às regiões NUTS III de Portugal, um país que apresenta características regionais contrastantes, tanto nas dimensões demográficas quanto económicas. Os resultados demonstram a urgência demográfica e apontam para a importância dos saldos migratórios no combate ao declínio da população na maioria das regiões portuguesas. Além disso, o artigo enfatiza a forte relação entre mercado de trabalho e migração, defendendo políticas integradas que abordem conjuntamente a dinâmica económica e demográfica.

Palavras-chave: Estimativas e projeções demográficas, Modelo de input-output, Políticas públicas, Desenvolvimento regional

Códigos JEL: J11, J18, R58, R15

1. INTRODUCTION

Population decline has been one of the most demanding phenomena in recent decades in various European regions. In the last ten years, although the European population has been reasonably stable, 37% of its NUTS III regions had a diminishing population (EUROSTAT, 2018). In most European regions, the drastic reduction in the workforce in agriculture has not been offset by other economic sectors. This led to decades of outmigration, generating a severe drop in population of fertile age, which, combined with low fertility rates, made it impossible to sustain population levels by internal natural balances (Bijak, 2006). Moreover, even in regions with positive a migratory balance, a negative demographic dynamic dominated by an ageing population persists. This ageing tendency results from a increased life expectancy combined with low fertility rates, paving the way for a decline in the working population, with all the known social and economic consequences. As such, demographic ageing and migration have become a widely debated research and policy topic (see for instance Newbold, 2018).

Demographic phenomena cannot be dissociated from their economic counterpart: the economy and demography interact, reinforcing each other in a circle of cumulative causation. In many peripheral European regions this cumulative causation leads to a vicious circle of decline (Johansson, Nilsson &, Westlund, 2018; Aksoy, Yunus, Basso, Smith & Grasl. 2019).

Successive waves of outmigration and low fertility rates generate an inverted age pyramid, where the scarcity of young entrepreneurial people, combined with the absence of dynamic economic centres, creates poor prospects for development. Moreover, because the demographic dynamics have a strong inertia – arising from an age structure, which can only change very slowly – such an impulse endures for a long time. Standard economic growth models do not consider demographic evolution as a restrictive factor (or constraint). Nevertheless, it is necessary to consider the possibility of scarcity of human resources. As such, demographic projection must be consistent with the economic trajectory and the corresponding labour needs as the main driver of migration. The challenges, arising from population decline and ageing, can only be addressed seriously if these drawbacks are overcome and the co-evolution of population and economy is considered and, in particular, if migration flows by age groups can be linked to labour supply and demand dynamics.

The demographic problem affecting Europe is neither new nor unknown (Cheshire & Hay, 1989). What is new is the scale of the processes involved and the diverging economic path they create in many regions. Demographic change stands both as a cause and a consequence of social, economic and environmental dynamics (Foreman-Peck, 2019). For political authorities, it is crucial to understand these dynamics to promote comprehensive strategies in local and regional development.

The challenge is to develop a decision support tool able to simulate the demographic dynamics - considering the differentiated age group migration tendencies, and also the specific regional characteristics that will account for the ability to attract or maintain population – conditional to the national economic evolution and the corresponding regional human resources requirements. This article presents a model which is capable of anticipating the quantitative evolution of the two most important key drivers of regional growth; on the economy side, the labour force needs and on the demography side, net migrations. We believe that this can be an essential element to support the design of such policies.

The demographic challenge being faced by Europe and Portugal is presented in section 2, demonstrating the central role of migration in demographic public policies. Then, in section 3, the link between net migration flows and job opportunities is demonstrated based on the regional data (Portuguese NUTS III regions) from the last three decades. In the next section, an interregional model is presented which is able to make interrelated projections of key regional demographic and economic variables. The complex and spatially interdependent set of relationships in the model are reflected in a system of multilinear relations that allow migration flows to be estimated based on regional economic growth and historical migration net flows. Finally, a discussion of the role of public policies in dealing with ageing population and depressed economies at the regional level is presented.

2. THE DEMOGRAPHIC CHALLENGE

2.1 In Europe

The EU-27 is facing the risk of demographic ageing and decline. This process will affect central and peripheral regions differently and, interacting with economic dynamics, it will shape new patterns of inequality, undermining the territorial cohesion objectives defined in the ESDP,[1] unless strong policy measures are taken and the required resources are provided.

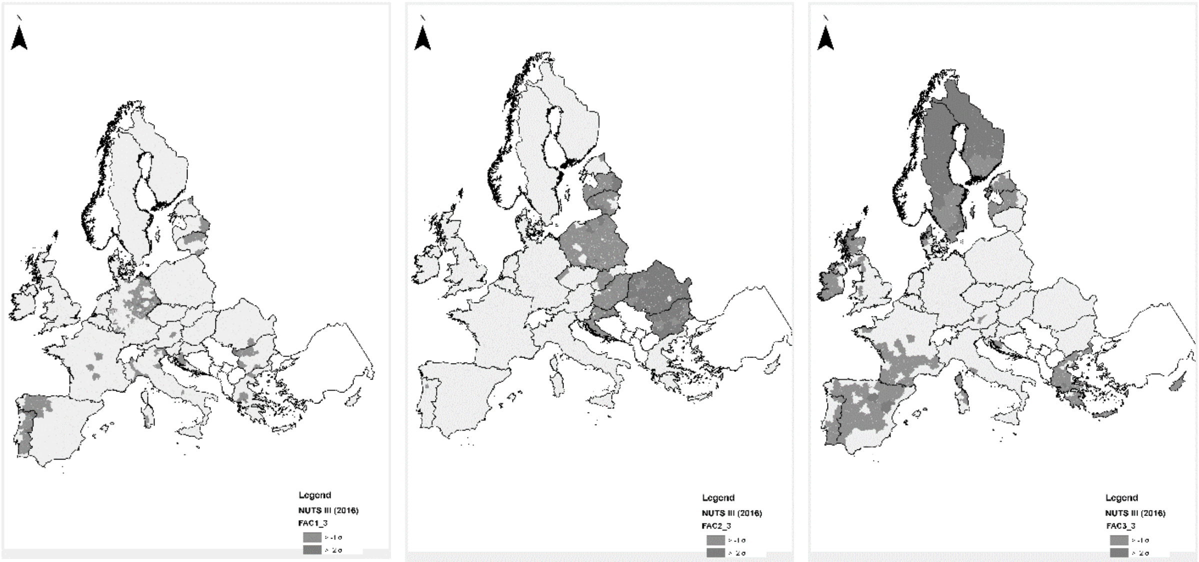
European regional disparities in terms of demographic and economic dynamics are briefly described in the following cluster pattern, generated by a principal component analysis (PCA) based on a small set of 2011 indicators, by NUTS III region (for more details please see Castro, Martins, & Silva, 2015): i) rate of population change (2001-2011); ii) weight of the population aged 65 and above; iii) weight of the population between 0 and 14 years old; iv) population density, v) demographic potential and vi) per capita gross domestic product (GDP), vii) Regional Innovation Score.

Three factors were extracted: i) *ageing process* (factor 1), combining the weights of young (loading = 0.88) and old (loading = -0.80) population; ii) *economic and demographic*

[1] *ESDP*, *European spatial development perspective*: *towards balanced and sustainable development of the territory of the European Union*, European Commission, Office for Official Publications of the European Communities, 1999.

dynamism (factor 2), defined by population growth and GDP *per capita* (loading = 0.85) and Regional Innovation Score (loading = 0.71)*;* and iii) *density of population* (factor 3), which includes population density (loading = 0.89) and Demographic potential (loading = 0.81). Figure 1 below shows the highest scores of each factor, those higher than 1 and 2 standard deviations.

Figure 1: Demographic and economic patterns of the European regions (NUTS III)

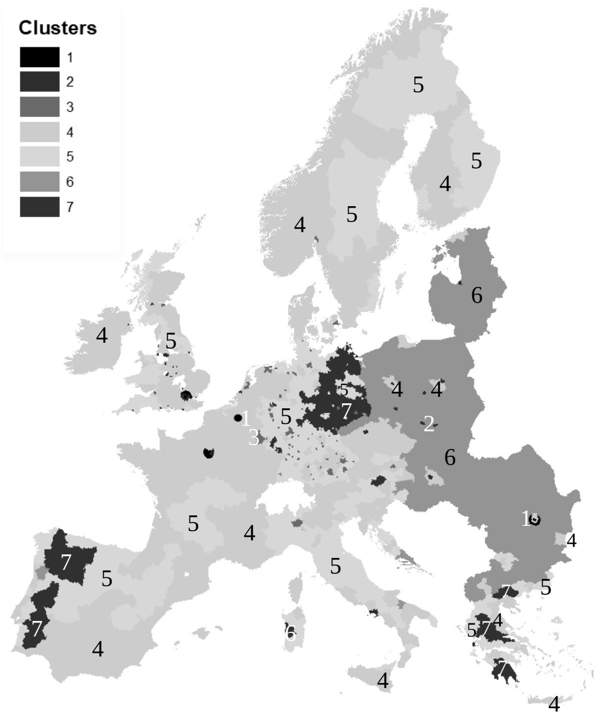


Factor 1 – The Europe of demographic decline | Factor 2 – The Europe of lagging economy | Factor 3 – The peripheral and low density Europe

Based on these three factors, seven clusters were defined (see figure 2).

- The *first* and *second clusters* represent rich and densely populated urban regions with positive population growth and a young population, such as the metropolitan cores of Brussels, London or Paris (cluster 1) or the metropolitan areas of Berlin, Prague or Budapest (cluster 2).
- The *third cluster* includes rich urban centres with a more aged population: Munich, Frankfurt, Hamburg, Vienna, Copenhagen, Oslo and Milan are illustrative examples. It must be noted that the geographical expression of this category is very small, which supports the argument that a dynamic economy is dependent on a favourable demographic evolution, with exception made for some particular regions such as those grouped in this cluster.
- The *fourth* and *fifth clusters* represent the majority of the NUTS III regions in the EU-27 (68.8%). They have average economic and demographic dynamism in terms of European standards, differing from each other according to age structure (cluster 5 has a more aged population).
- The most depressed regions in the EU-27 are represented by the *sixth* and *seventh* clusters. The *sixth cluster* shows a globally depressed situation, but performs better than cluster 7 in terms of density and age structure. It includes 189 NUTS III located in Eastern European countries.
- The *seventh cluster* includes 103 NUTS III regions with negative population growth and low GDP per capita and with a particularly poor performance in terms of population density and aged population. This cluster brings together the most depressed peripheral regions, forming three main groups: the former East Germany and adjacent areas, with the exception of Berlin and a few urban centres; a set of Greek rural areas; a strip of regions which run from north to south along the border between Spain and Portugal. The regions of this cluster provide a particularly interesting case study, given its considerable size and its peripheral location in terms of the EU, where the negative causation process between the economy and demography is more important. Thus, in these areas, adequate public policies are even more necessary.

Figure 2: NUTS III regions of the EU-27 according to the seven clusters



Cluster	ageing process	economic and demographic dynamism	density of population
1	++	++	++
2	++	- +	+
3	-	++	+
4	++	+	- +
5	-	+	- +
6	+	- -	+ -
7	- -	- -	-

2.2 In Portugal

In Portugal, the ageing process took place suddenly and sharply, affecting the interior part of the country in particular. Among the twelve NUTS III of the EU-27 with the highest old-age ratio, six are Portuguese peripheral regions (see Table 1).

Table 1: Population variation (2001-2011) and ratios of the NUTS III regions of the EU-27 (2011) with the highest share of elderly population

Country	NUTS III	Old age ratio (65+)	Young age ratio (0-14)	Population variation (2001-11)
Portugal	Pinhal Interior Sul	33.7%	10.4%	-8.0%
Greece	Grevena	29.1%	12.0%	-5.9%
Portugal	Serra da Estrela	28.8%	11.0%	-11.3%
Portugal	Beira Interior Sul	28.7%	11.5%	-2.7%
Portugal	Beira Interior Norte	28.7%	11.5%	-8.1%
Greece	Evrytania	28.5%	10.4%	-3.7%
Germany	Dessau	28.3%	9.6%	-9.9%
Spain	Ourense	28.2%	9.5%	-3.1%
Spain	Zamora	28.0%	10.0%	-2.9%
Portugal	Alto-Trás-os-Montes	27.8%	11.2%	-7.4%
Spain	Lugo	27.5%	9.4%	-3.3%
Portugal	Alto Alentejo	27.4%	12.7%	-4.8%
Germany	Görlitz	26.8%	11.2%	-9.0%

Source: EUROSTAT (2001, 2011)

The Portuguese demographic evolution is a clear example of population concentration along the coast, driven by a process of continuous urban and industrial agglomeration. Conversely, there was a significant decline and ageing in the peripheral NUTS III regions, in spite of the increase in the total Portuguese population (Magalhães, 2003; Castro, Martins, & Silva, 2015 and Gomes, Silva, Castro, & Marques, 2016). Since the last censuses, the migration net flow has been insufficient to counterbalance the negative natural growth, and the population in these peripheral has been decreasing (Craveiro et al., 2017).

Portugal is an ideal case study to model the relationship between employment opportunities and migration flows because it presents sharp contrasts between the economic development of coastal regions and demographic and economic depressed peripheral regions (Castro, Martins, & Silva, 2015).

Figure 3 identifies the Portuguese NUTS III, which can be considered Portuguese Peripheral Regions (PPR) and the coastal areas. Figure 4 presents a synthesis of demographic changes by NUTS III in the last three decades. The coast-periphery division is clear with few exceptions, to the extent that population in the PPR decreased, while on the coast there was general growth. In addition, more than half of the coastal regions showed a population increase greater than 25%, while the PPR lost nearly a third of their population.

Figure 3 – Portuguese peripheral regions

Figure 4 – Population growth rates (1981-2011)

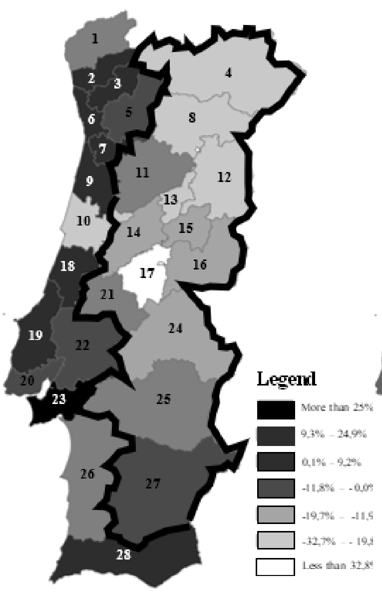
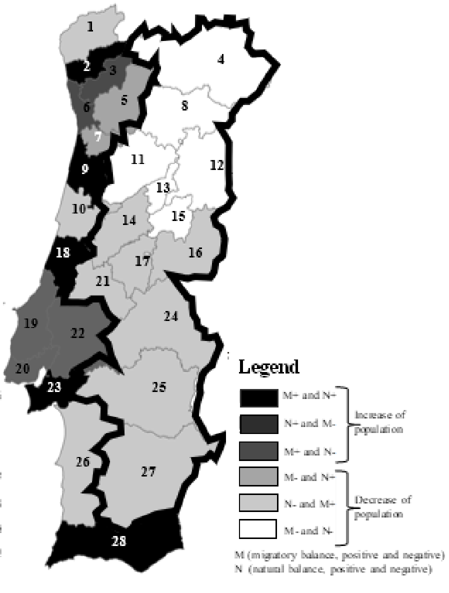


Figure 5 – Population growth by components (2001-2011)

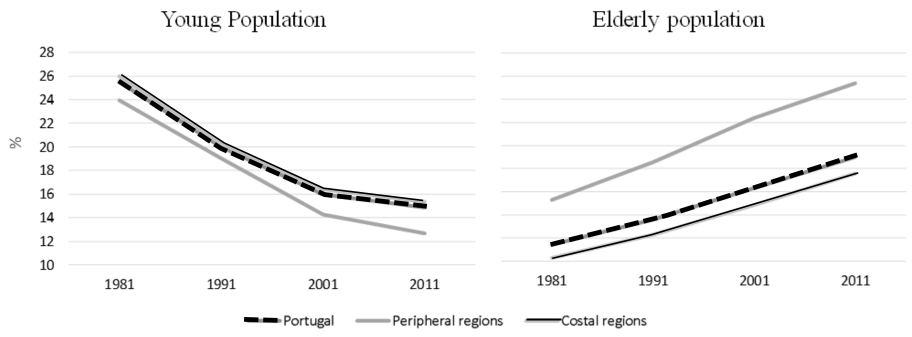


Source: Statistics Portugal

The main source of growth in the last two decades was net migration, as in the majority of developed countries (Sarra & Del Signore, 2010), while the growing contrast between the coast and the periphery was caused both by differences in natural growth and net migration. Throughout this period, a clear coast/periphery dichotomy prevails, but a new differentiation seems to emerge between the north and the south of the national territory with a deeper decline in the interior-north (see Figure 5).

Along with population change, the ageing process took place quickly and intensively. Since 1981, the proportion of young population (0-14 years old) has decreased in all regions, though less markedly in the coastal NUTS III. The opposite occurred in the evolution of the elderly population (older than 65 years), whose proportion increased across the period, with a stronger incidence in the PPR (Figure 6). Population ageing, with a consequent deficit of young fertile adults, is a serious barrier to long-term growth, which can only be overcome by strong immigration flows.

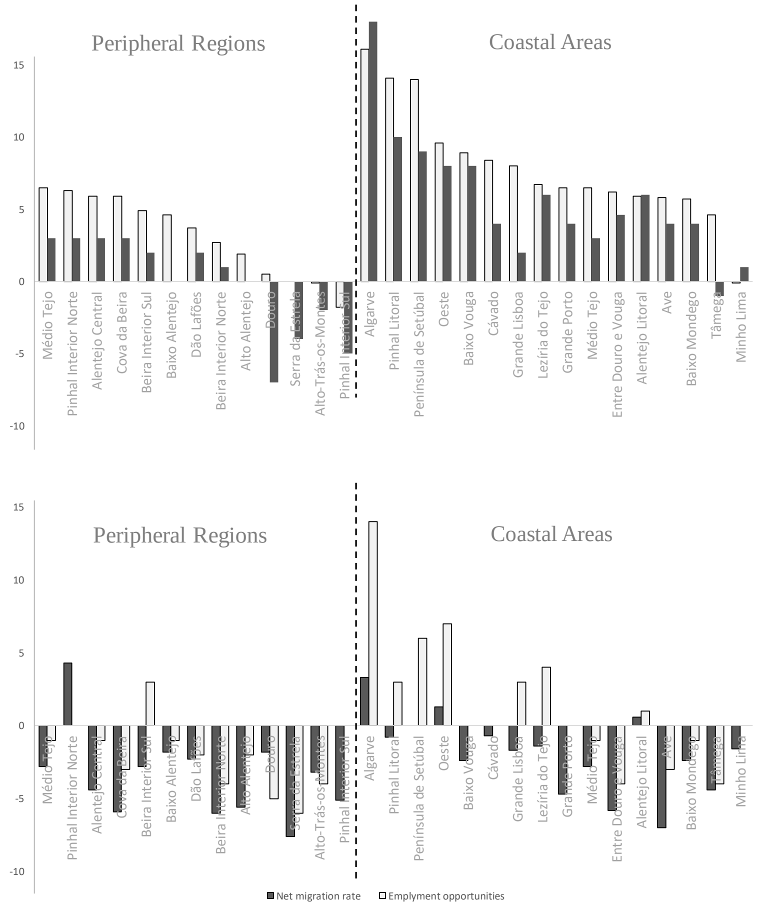
Figure 6: Population growth by major age groups (1981-2011)



Based on this conclusion, it is critical to analyse interregional migration flows in Portugal in order to provide the necessary information to support the design and implementation of policies which are able to retain and attract a young population. Other studies in this area point out that the main drivers for this type of migration flows are economic, related to employment opportunities and better wages although regional characteristics play also an important role in the migration decision (Biagi, Faggian, & McCann, 2011; Sarra & Del Signore, 2010).

In Portugal, it is possible to observe a similar migration pattern, which is different between the coastal and peripheral regions (see 7). In the PPR, there is a tendency for emigration, even in situations of the creation of job opportunities (namely in Serra da Estrela, in the second period), and in the coastal regions the opposite situation occurs – immigration is higher than the existing job opportunities.

Figure 7: Migration and job opportunity creation rates for the Portuguese NUTS III regions



Source: Statistics Portugal and Castro et al. (2013)

3. INTERREGIONAL MIGRATION MODEL FOR PORTUGAL – METHODOLOGY

This model relies on two main principles: the first states that economic and demographic dynamics are interrelated in a single regional growth process; and the second is that the nexus between the demographic and economic components corresponds to a dynamic overlapping generations model (Raymer & Rogers, 2007).

When an exogenous economic change occurs in a region in time *n*, there is an effect on regional production and employment which may induce net in- or out-migration of the active population and dependents – those less than 65 years old (Lee, 1966; Niedomysl, 2011; Termote, 2003). Migrations are also driven by stimuli other than employment opportunities, such as return of elderly people, somewhat reversing the trends which occurred in the past (Wiseman, 1980; Zlotnik, 2003). The demographic dynamics induce endogenous changes in demand, which, added to new exogenous changes, define regional production and employment in time *n + x*, which in turn cause new waves of net migration. It should be stressed that inside the Eurozone, given the absence of an exchange rate device, regional migrations are actually the main adjustment mechanisms available to regional economies when hit by economic shocks (Ramos, Castro, & Cruz, 2011).

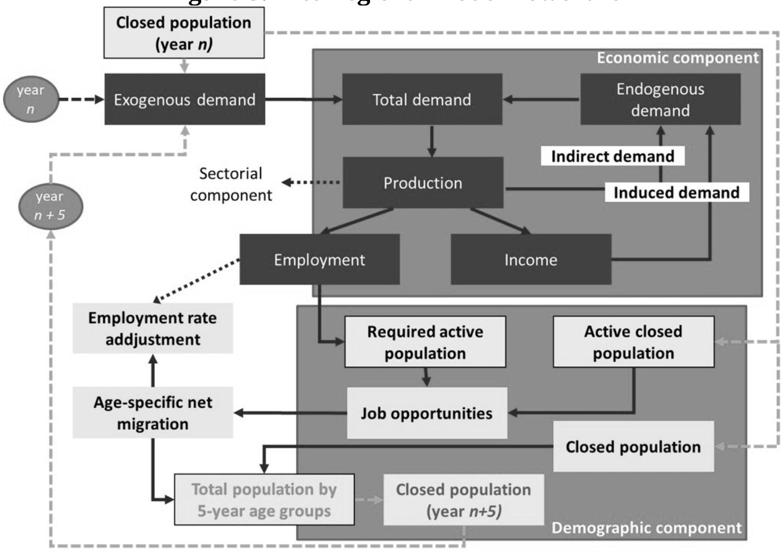
The model's functioning is generally described in Figure 8. An exogenous change in demand or in productivity has a direct impact on production, employment and income, which in turn induces changes in endogenous demand and again in production, employment and income, through a cumulative process typically described by multiplier models (Østbye & Westerlund, 2007). The regional employment needs, calculated by this cumulative process, are denominated as *economic employment.* In parallel, the regional demographic dynamics define the expected population structure which will occur in the absence of migrations (closed population), driven by births, deaths and ageing. Assuming that the rate of employment by age group and sex is kept constant between years *n* and *n + 5*, the value of closed population will give an expected level of employment which is denominated *demographic employment*.

The coherence between economic and demographic dynamics is ensured by assuming that the values of *economic* and *demographic* employment are equal, with migration flows of people under 65 years of age being the mechanism which creates such a balance (Overman, Rice, & Venables, 2010; Termote, 2003) along with employment rate adjustments. Migrations of persons older than 65 (retirement age) are assumed to be indifferent to the employment dynamics. Nevertheless, the migration of the population of this group age is important as it induces a new change in demand which must be incorporated into the model (Ramos et al., 2011). The successive inclusion of exogenous changes (varying according to several proposed scenarios which include information related to regional final demand, productivity and evolution of the fertility rate) and endogenous reactions (concerning ageing and migration) feeds the model up to 2030, the target year for the forecast of regional demographic and economic structures for all the PPR (see Figure 8).

The adopted scenarios are the combination of changes in the outside world with the result of specific national policies. An alternative methodological approach would have an estimation of future economic dynamics using economic growth models, such as dynamic computable general equilibrium models (Pouliakas, Roberts, Balamou, & Psaltopoulos, 2014), which require less information for each interaction but are more demanding on information for the baseline year and calibration process. Given the time horizon adopted and the uncertainty of economic evolution, intensified by the 2008 crisis, the analysis of economic dynamics conditional to a broad set of scenarios is considered to be a more reasonable option. It is also to be considered that the model was design to be used as a decision support tool, and as such, it was not intended to produce exact predictions but only to produce policy impact assessment, conditional to scenarios defined by policy makers.

In summary, the model is composed by two blocks: economic and demographic, which interact with each other exchanging data concerning human resources required (economic block) and human resources available and retired population (demographic block). A more detailed description of the blocks and of its interaction is presented in the following sections.

Figure 8: Interregional model flowchart



3.1 The economic block

The multiplier mechanism described above is modelled using an input-output methodology (Marques, Martins & Castro, 2006). For this purpose, 15 matrixes were built, one for each PPR and another one for the rest of the country. It must be emphasized that such regional matrixes are not provided by Portuguese official statistics and that it was the first time that NUTS III level input-output matrix had been calculated.

The point of departure was the national rectangular input-output table for 2007 with 125 industries and 431 products. This matrix, defined in domestic flows and basic prices, was then regionalised, using a methodology which can only be sketched out in this paper but may be seen in detail in Ramos et al. (2010) and in Ramos, Barata, & Pimentel (2013). The final consumption vector was disaggregated in two categories, discriminating households headed by people over and under 65 years old.

As the regional vectors of total production and consumption are available, the main problem was the absence of information about interregional imports. To identify the fraction produced in the region for each input, two main steps were carried out. First, each of the 431 products were carefully analysed and allocated to three categories: A – regionally non-tradable products, which must be consumed in the region where they are produced (such as construction, retail services, public administration or education); B – fully tradable products internationally or interregionally; C – special cases, where intermediate situations were admitted. In general, increases in demand for products A are totally satisfied locally, while increases in demand for products B are only locally met in a proportion corresponding to the regional contribution to the respective national output. Finally, C products are either tradable between neighbour regions (high shipping costs) or correspond to services which are delivered locally by nationwide companies with a significant part of the business activity accounted for in the headquarters' region (banks, insurance, etc.). It should be mentioned that backward linkages of PPR result mainly from type A products, as most of the indirect and induced effects of the other products are leaked to central regions or to other countries.

Once the 15 matrixes were built, it was necessary to define scenarios for the future evolution of the exogenous variables. As stated before, a population under 65 years old is endogenous (consumption and labour earnings) and adjusted to economic growth through migration flows. As can be seen below, migrations of elderly people are exogenous to the economy but, rather than being defined by scenarios, they will be estimated in the demographic block of the model and impact the economic model through consumption.

Several scenarios were designed and tested in order to understand both the model's response and to set the range of change of the exogenous variables according to different possible evolutions of the worldwide economy. As an example, two of them are presented (see Table 1):

- Economic scenario I (S_E_I), null growth, is a baseline scenario where all control variables are kept constant, with the exception of the period affected by the financial crisis of 2010-14, where economic decay is considered to be followed by a recovery to the values of 2010;
- Economic scenario II (S_E_II), heterogeneous growth, admits moderate growth in competitiveness, leading to growth in exports, considering that the country is not affected in a homogenous manner by this economic development. Three types of performance were considered: $S_E\_II.1$ – regions where the exogenous demand grows more (metropolitan areas and Algarve); $S_E\_II.2$ – regions with a moderate growth (including the more dynamic PPR); and $S_E\_II.3$ – regions that maintain a null growth scenario (most of the PPR).

Table 1: Selected scenarios for the economic evolution

Scenarios	S_E_I	$S_E\_II.1$	$S_E\_II.2$	$S_E\_II.3$
Consumption by the elderly (per capita)	Constant	Constant		Annual decrease (1% up 2020 and 0.5% up 2030)
Productivity		Grows annually with different sector paths: 2% in the primary and secondary sectors and 0.5% in the tertiary sector; the gains spill over to the employers		
Exogenous demand (without public sector)		Exports growth 2% and GFCF growth 1% annually	Exports growth annualy 2%, [the other components are constant]	
Public sector demand		Annual growth of 1%	Annual decay of 0.5%, between 2010 and 2020	Annual decay of 1%, 2010 -2020 0.5%, 2020-2040

The results obtained by the economic block of the model are key inputs for the demographic block, described in the following section.

3.2 The demographic block

The central elements of this block are demographic projections for each of the Portuguese NUTS III regions, by five-year age groups and sex. They are based on the cohort component method and they are made for 5-year intervals up to 2030 (Preston, Heuveline, & Guillot, 2001). The projections for the year *n + 5* are obtained in two phases from year *n* data. In the first stage, the close population is projected assuming null net migrations for all age groups, based on estimates fertility and mortality rates – designated as *closed population*. The demographic employment is then calculated, based on employment rate for the year *n*. The comparison between economic and demographic employment is the basis for the estimation of net migrations for year *n + 5* (as described in Figure 8).

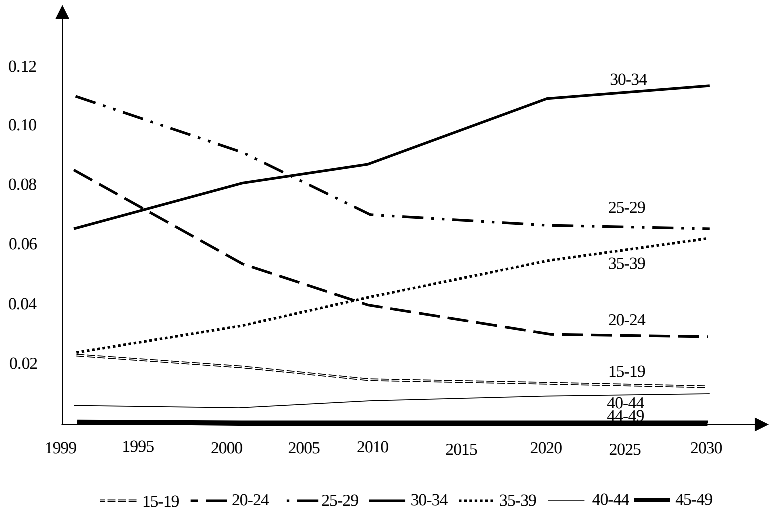
Closed population

To calculate *closed population*, considering only the natural balance, it is necessary to estimate the future values of mortality and fertility rates, extrapolating the behavioural patterns observed in recent decades.

Mortality time series have a small regional heterogeneity and a relatively smooth pattern of decline. As a consequence, independent regression estimations for each age group, sex and region were performed.

The estimation of fertility rates is more challenging (Castro, Zhang, Bhattacharjee, Martins, & Maiti, 2015), because heterogeneity is considerably larger and because the pattern has changed in recent years (see Figure 9), reflecting cultural, social, and economic development (Gomes, Silva, Castro, & Marques, 2016). The total fertility rate (TFR) is generally declining in Portugal, with birth rates now depending on economic factors rather than on culture; as a consequence, fertility rates are higher in the more affluent regions, a pattern which reverses the past situation. Along with these regional changes, the age distribution of fertility has also significantly changed, decreasing for younger ages (15-29 years old) and increasing or stabilising for older women (30-49 years old) (see Figure 9).

Figure 9: Five-year age-specific group fertility rates



Source: Statistics Portugal and Castro et al. (2013)

In addition to heterogeneity, a significant pattern of spatial autocorrelation was detected. To deal with both problems, a procedure of smoothing on estimations of fertility for each quinquennial age group and region was used. This means that the estimation considered a more complementary and robust information, using shrinkage methods, borrowing strength from spatially related regions, consecutive years, and relevant age groups (the detailed explanation of this procedure is presented in Castro, Martins, & Silva (2015) and Gomes, Silva, Castro, & Marques (2016).

This methodology was applied in order to obtain two alternative scenarios for the evolution of the fertility rate that are used with the corresponding economic scenarios. Demographic scenario I (S_D_I) corresponds to the projection of the fertility rates by age group and region according to current tendencies, while demographic scenario II (S_D_II) admits a positive evolution of the total fertility rate to 1.5 children/women in 2060, in Portugal. In both cases, the regional and age-group heterogeneity is preserved.

Net migrations

All net migrations are estimated for each 5-year period by comparing the local supply of human resources (*demographic employment*, E_d) with the employment calculated in the economic block (*economic emploment*, E_e). The parameter E_d corresponds to the number of employees available in the region if there were null net migrations and if the employment rate was kept constant in the period (Lisenkova et al., 2010); and E_e is the employment determined by the input-output model for each economic scenario. The difference between both types of employment is the key explanatory variable for the net migrations in each age group; other variables such as *GDP per capita* and *demographic potential* were added, with the time lagged net migration rates also being included in order to capture the effect of elderly people returning to their regions of origin. Migrations for people younger than 15 years old will be made dependent on the migration pattern of migrant mothers, assuming that they have the same fertility rates of the resident women.

The parameters necessary to project future migration flows were estimated using a regression model applied to two successive decades (1991-2001 and 2001-2011) (for more detail please, see Martins, Silva, Marques, & Castro, 2011). There is an independent regression equation for each age group and sex, which simultaneously estimates net migration rates for all regions and both decades – a multiregional perspective (Rogers, 1990). The model provides an accurate explanation of migration behaviour for active age population up to 49 years old (adjusted R square above 80%), maintaining good scores (near 70%) for the older age groups up to 74 years old (Martins, Marques, & Silva, 2013). The model is described by the following equation:

$$_5M_{xrt} = A_{xrt} + \alpha\left(\Delta E_p\right)_{rt} + \beta\left(\Delta E_{np}\right)_{rt} + \delta(\Delta GDP)_{rt} + \varphi(\Delta Pot)_{rt} + \gamma i \;_5\left[\,_5\left(\,_nM_{x-i}\right)_{t-i}\right]_{xrt}$$

where:

$_5\boldsymbol{M_{xrt}}$ is the observed net migration in each decade *t* for each age group *x*, sex and region *r*;

$\boldsymbol{A}$ is a constant; it represents the propensity to migrate when the economic and demographic situation of the region does not change, that is when the explanatory variables are all equal to zero (see the sociological and political approach theories of migration, referred in Zlotnik, 2003);

$\Delta\boldsymbol{E_{rt}}$ is the variation of employment opportunities in the region *r*, corresponding to the difference between *economic* (E_e) and *demographic employment* (E_d); because the reaction to variation in employment opportunities is expected to vary considerably between the primary (*p*) and non-primary (*np*) sectors, ΔE_{rt} was divided according to these two categories;

$\Delta\boldsymbol{GDP_{rt}}$ is the ratio between GDP per capita in the region and the national GDP per capita; it is an explanatory variable which responds to the economic approach theories of migrations (Zlotnik, 2003) and to the migration modelling theoretical framework (Gaag, Wissen, Rees, & Stillwell, 2003; Termote, 2003);

$\Delta\boldsymbol{Pot_{rt}}$ is the ratio between the *demographic potential* in the region and the weighted average of the *demographic potential* of all the regions, where the weights are the population of each region. This variable models the effect corresponding to the second and third Ravenstein laws (1985), i.e., the attrition of distance will induce a positive value in the coefficient φ, while the trend to move upwards in the urban hierarchy will have an inverse effect and thus the final value of φ will represent the balance between these two opposite effects; in short, this explanatory variable represents a gravitational approach of the distance factor (Niedomysl, 2011; Termote, 2003) and may reflect the influences of the spatial distribution of the population across the territory (Rogers, 1990);

$_n\boldsymbol{M_{x-10}}$ (or $_nM_{x-20}$, ...) is, for the age group *x* to *x + 5* years and for the period *t* to *t + 10* years, the net migration for the period lagged by 10 (20, ...) years and when the population of this cohort *i* was 10 (20, ...) years younger. For example, net migration of the age group 60 to 65 in the ’90s was considered dependant on net migration of the 50- to 55-year-old population in the ’80s and to the migration of the 40 to 45 years age group in the ’70s, etc.

Since migration data for Portugal is scarce, it was necessary to estimate net migrations between censuses as the difference between the population which occurs if net migrations in that period were zero (*closed population*) and the actual population – the *forward method* (Nazareth, 2000).

3.3 Integration of the model

As explained above, this model aims to capture the interaction between economy and demography. This interrelation is highlighted when: i) the economic evolution is exogenous (evolving according to economic scenarios) and net migrations are endogenous (model driven by economy); ii) net migrations are the drivers (corresponding to different demographic scenarios) and employment is an endogenous variable (alternative model driven by demography); and iii) economy and demography evolve together (interregional migration model).

i) Economic driven model

In the first approach, it is considered that all of the economic employment needs (positive or negative) will be satisfied through (in- or out-) migration. This approach is considered to be appropriate in economic dynamic regions that attract new residents by ensuring better changes to find jobs, better wages and also by having better quality of life indexes, connected with cultural and social services, access to public services and other local amenities (Biagi et al., 2011).

Nevertheless, in more depressed regions, the existence of job opportunities by itself is insufficient to ensure in-migration and the natural growth dynamics are insufficient to provide the necessary work force. Rural areas in Portugal have traditionally experienced difficulties in retaining the young population, who tend to move to metropolitan areas independently of the economic regional context.

This methodological approach led to unreasonable migrations estimates for most of the PPR, and it was concluded that it was not suitable for the characteristics of the Portuguese in land region, as well as other demographic and economically depressed regions.

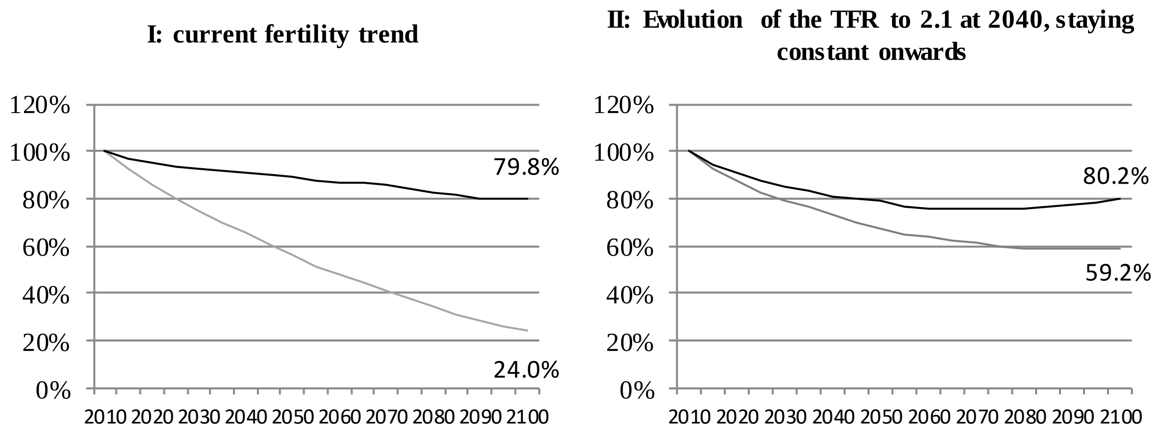
ii) Demography driven model

In this application, the model is adapted to evaluate the number of new migrants and jobs required to obtain population levels corresponding to different scenarios (McDonald, 2002); in this approach the economy is treated endogenously in order to provide the targeted number of jobs.

In the first step, the demographic block provides closed population forecasts, considering two demographic hypotheses (see Figure 10): in *Demographic Hypothesis A*, fertility would evolve under the current trend; in *Demographic Hypothesis B*, the TFR grows steadily from the present value to 2.1 children per woman in 2040 and is constant thereafter. In the former (A), the population decreases continuously, whereas in the latter (B), a stationary population is attained near 2085, although with a considerably smaller size in comparison to the present value.

Considering now the target of obtaining a long-run stationary population which is 80% of the 2011 level, the gap between such values and the closed population projections was calculated. As an example, the results obtain for one PPR – *Pinhal Interior Sul* – are presented in Figure 10 and show the great differences between the two hypotheses.

Figure 10 – Closed population projection in grey; transition curve to a stationary population in black, for *Pinhal Interior Sul* Region based on two hypotheses: I and II



Both results are indicative of the dimension of the problem: to ensure a population corresponding on 80% of the present one, an unrealistic number of immigrants would be necessary (in hypothesis A) or an unrealistic fertility rate (in hypothesis B).

In summary, the low fertility implied in hypothesis A is only compensated by an unrealistic permanent stream of in-migration due to the creation of jobs, which can attract newcomers. On the other hand, a recovery in fertility allows a smoother transition over a long period and is also unlikely to occur to this extent since changes in fertility are not a policy goal, which can easily be attained with an incentive programme. As final remark, it must be stressed that the values provided up to 2100, rather than being predictions, merely represent a benchmark that enables a better understanding of what is at stake in the PPR dynamics.

iii) Interregional migration model

Analysis of the results of the models presented above lead to the conclusion that the most suitable methodological approach should not subordinate one of the dimensions to the other, but allow economy and demography to evolve together, with the driving dimension being reflection of the regional characteristics and not chosen in advance.

Thus, after obtaining the job opportunities (the difference between *Ee* and *Ed*) by NUTS III, the first step is to allow the employment rate to be adjusted in order to obtain the reaction of the local population to those job opportunities both by participation in the labour market and by migration. Thus, the age-group employment rate is adjusted following a logistic function (age group specifics), considering that there are superior and inferior limits to the employment rates. This solution diminishes the need for in-migrants when job opportunities are positive, but it also diminishes out-migration when the regional economy is declining. It must be pointed out that economic employment is dependent on the total resident population, and as such, the reduction of the number of migrants also reduces the human resources needs.

4. RESULTS OF THE MODEL APPLICATION

The application of the intraregional migration model jointly considering the economic and the demographic scenarios described in the previous section led to troubling results (see Table 3 and Figures 11 and 12) that, once again, reinforce the need to reflect on the demographic challenge of the peripheral regions in Portugal.

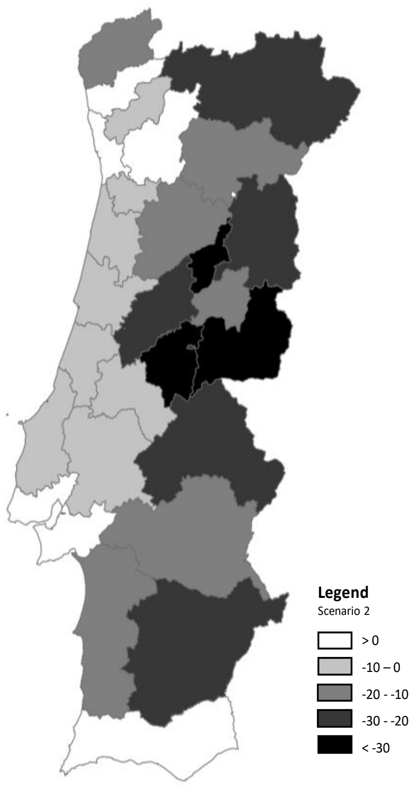
In the first scenario, assuming constant evolution both in the demographic and economic dimensions, a significant decrease in the Portuguese population is expected between 2010 and 2040 (-1.7 million), which, even so, is dependent on an in-migration flux from 2025 (for more detailed information, see Castro, Martins, & Silva (2015). Thus, without no economic impulse and assuming a business-as-usual evolution of the fertility rate, Portugal would face a disturbing situation –a population decrease of 16%, which is even more dramatic in the inland areas (-25%).

Table 2: Population evolution

Region	Population 2010	Scenario I - 2040			Scenario II - 2040		
		Population	Cumulative migration	Variation	Population	Cumulative migration	Variation
Portugal	10 562 178	8 880 341	-445 960	-16%	10 252 898	775 866	-3%
PPR	1 925 392	1 452 472	-20 131	-25%	1 557 446	72 818	-19%
Coastal regions	8 636 786	7 427 869	-425 829	-14%	8 695 452	703 048	1%

Figure 11 – Population growth projection for 2040, under scenario I assumptions

Figure 12 – Population growth projection for 2040, under scenario II assumptions



The heterogeneous growth scenario resulted in a population volume similar to the current one (10.3 millions), heavily dependent on the country's capacity to attract a younger population from abroad, mainly in the coastal regions. This scenario perpetuates the historical trajectory: the coastal regions' economic and demographic development are key in national growth, and the peripheral ones fall behind as they are unable to create or even maintain employment and to retain population. It is interesting to note that the regions that are able to present a positive evolution are the ones that have more favourable economic contexts (metropolitan areas) or a combination between favourable demographic characteristics – younger age structure – and positive economic environment (Cávado and Tâmega).

It is important to retain that even in the catastrophic situation represented, both in scenario I and II, for the PPR, where the population decreases 25% and 19%, respectively, it is assumed that these regions are able to attract migrants. Under these scenarios, the economic decline of the current decade will generate moderate levels of out-migration, while the slightly better conditions of the forthcoming decades can only be met with an influx of newcomers.

This short analysis supports the conclusion that integrated public policies are of crucial importance for focusing on migration, both in Portugal and in other countries with strong regional disparities and ageing population.

5. CONCLUSION

The need to change population and regional development public policies is clear, based both on the current population indicators and on the estimates presented. The assumption that labour resources are perfectly mobile is not valid in peripheral regions, in Portugal and in Europe alike. For this reason, it is necessary to invest further in the development of models able to provide insights into the efficiency of development policies and on their impact on demographic evolution. Thus, the challenge is twofold: to redirect the regional public policy approach, comprehending the demographic fragilities, and to develop new decision support tools able to increase the regional development policies efficiency and effectiveness.

5.1 Methodological challenge

The research presented in this paper revealed how serious the human desertification problem is in peripheral regions and how difficult it will be to reverse the trend. It also showed that only attracting younger people through job opportunities can diminish or even reverse the situation. This statement highlights the interdependency between economy and demography.

A model was developed to tackle the problem, defining migrations as the main link between the economic and demographic dynamics. Migrations of older people, in spite of being an important demographic element in PPR, rather than being driven by job opportunities, correspond fundamentally to the return of people who left the region in the past decades. Finally, migrations of younger people (under 14 years old) reflect parents' behaviour. Combining these three components, the model provides an accurate description of migrations in the last two decades, conferring a reasonable confidence to its extrapolation to the next thirty years.

The demographic and economic depression problem was addressed by looking at the particular case of Portuguese peripheral regions. Nonetheless, considering that many other regions in Europe are witnessing the same ageing effects, the model could be further validated for these other regions.

The results show the potential of this tool as valuable aid in the support for decision-making in the design of public policies to address these problems, namely by testing their impact in the long run.

As far as the methodology is concerned, this research stimulated the development of new techniques to improve demographic projections and to build input-output matrixes at NUTS III level, based on the national matrix and on regional data. The model is being improved through research in a simultaneous estimation of migration and employment rates for all regions using Bayesian inference.

5.2 Public policy challenge

Public policies can influence the evolution of a population by influencing mortality, fertility and migration. This can occur either by policies that aim specifically at demographic changes or by policies in other fields which have an impact on the population's behaviour. Mortality is mainly influenced by health policies and policies affecting living conditions. Fertility policies have been implemented in many European countries but their effectiveness has been questioned (Höhn, 1988). Therefore, migration balance remains as a major factor able to counteract the demographic winter.

On a regional scale, the major factors of attractiveness that can be influenced by public policies are the availability of jobs, amenities and housing, as well as different taxation regimes (Cebula, 1974; Clark & Hunter, 1992).[1] Strategies for countering population decline in low-density territories, such as the PPR, have been based on all these dimensions. In particular, countries with a history of receiving a large number of migrants, such as Canada, Australia or New Zealand, adopted policies to divert the migrant influx away from the major urban areas (Wulff, Carter, Vineberg, & Ward, 2008). The impact of these measures is still unclear, but programmes in some of the more remote provinces in Canada, based on facilitating the integration of immigrants into the labour market and the community, appear to show that at least some success is possible (Carter, Morrish, & Amoyaw, 2008; Derwing & Krahn, 2008).

In Europe, efforts to counter the demographic decline in low-density territories have also been adopted to some extent. In many cases, these efforts are integrated into broad policies to increase the attractiveness of the areas through place marketing strategies (Hospers, 2011) or policies directed at diversifying the regional economy or increasing the liveability of the territories. In more rural areas, the main focus is the development of tourism (Briedenhann & Wickens, 2004), but also of energy production or agriculture (Küpper, 2011). The attraction and retention of population does not exclude other measures. Germany many municipalities have, for example, resorted to developing child support services or paying a premium to every child that gets born (Küpper, 2011).

Case study evidence suggests that (at least at the local level) policy measures can contribute to slowing or reversing demographic decline (see, for example, www.dart-project.eu/). However, if we can find various examples of policies to attract migrants to specific localities in the literature, comprehensive programmes to deal with major problems such as the general decline of Portuguese and Spanish peripheries or the hollowing of East Germany have not yet been addressed. In these cases, countering demographic decline needs creative and integrated approaches which simultaneously deal with the different dimensions that are relevant for the population's behaviour.

Models able to integrate the interdependent economic and demographics dynamics, focused on future labour needs and on regional ability to attract and retain population, conditional to macroeconomic scenarios, are crucial in order to make previous efficiency analysis to the now policy approaches to this complex problem. With the support decision tool presented, decision makers can better plan their regional development policies, basing their decisions on scientifically calculated forecasts.

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[1] Naturally, their relevance is very scale dependent. Küpper (2011), for example, argues that job availability is a major factor on the regional level, while on the local level, housing and land prices become increasingly important.

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