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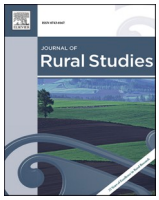

Financial exclusion, depopulation, and ageing: An analysis based on panel data

Ma Pilar Alonso [a], Pilar Gargallo [b,1,*], Carlos López-Escolano [c], Jesús Miguel [b], Manuel Salvador [b,1]

[a] Facultat de Lletres/Departament de Geografia, Historia i Historia de l'art./Universidad de Lleida, Pl. Víctor Siurana, 1, 25003, Lleida, Spain
[b] Facultad de Economía y Empresa/Departamento de Economía Aplicada/Universidad de Zaragoza, Gran Vía 2, 50005, Zaragoza, Spain
[c] Facultad de Filosofía y Letras/Departamento de Geografía y Ordenación del Territorio/Universidad de Zaragoza, San Juan Bosco, 7, 50009, Zaragoza, Spain

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ABSTRACT

This paper focuses on the relationship between rural depopulation and territorial financial exclusion. We provide a replicable statistical methodology to identify the existing patterns at municipal level based on the degree of financial exclusion caused by the absence (named as Type I financial exclusion) or paucity (named as Type II financial exclusion) of bank branches. Firstly, the extent to which the sociodemographic characteristics of a municipality influence its degree and type of financial exclusion is analyzed by using panel data regression models. Secondly, by means of cluster analysis techniques, a typology of municipalities is provided that takes into account their sociodemographic characteristics as well as their availability of bank branches. Within this context, this paper explores the case of Aragón (Spain), a European region with significant depopulation and over-ageing problems. Our results show a lack of homogeneity across Aragonese municipalities, both in the processes of depopulation and financial exclusion. This heterogeneity has led us to propose financial inclusion measures tailored to the population size as well as the degree of ageing, the employment possibilities, and labor dynamism of each group of municipalities. In other words, this paper reveals the need to propose measures that accommodate each territory's peculiarities, which could contribute to the achievement of sustainable territorial development in Aragón.

1. Introduction

Despite the fact that depopulation seems to be a recent event, it is a process that we could almost label as historical, especially in rural areas. Rural decline is an inevitable process (with few exceptions) as human society transforms from an agrarian into an urban-industrial economy, and further on into a tertiary knowledge economy (Li et al., 2019). The lack of jobs and opportunities makes it increasingly difficult to keep the population in their territories of origin, especially young people, who are compelled to migrate to areas offering more opportunities (Pérez-Morote et al., 2021). Additionally, more women than men leave rural regions, because employment options are even more limited for them (Johansson, 2016), which creates the phenomenon known as "rural masculinization." This decreases birth rates, which in turn creates negative natural growth. This fact, together with the increase in life expectancy, mainly due to better living conditions and advances in medical science, leads to the pronounced ageing of the population (Bongaarts, 2009). The existence of over-ageing in some depopulated territories is also indicative that the proportion of working-aged people is decreasing, causing their economic dynamics to decline (Abades and Rayon, 2012). In short, depopulation and ageing processes are strongly connected in rural areas, together with the lack of generational replacement and entrepreneurial capacity associated with the limited presence of young people and women (Reynaud and Miccoli, 2018). In Europe, these phenomena mainly occur in Southern Mediterranean countries and in some Northern and Eastern European areas (Pinilla et al., 2008; Rizzo, 2016; Náñez-Alonso et al., 2022b).

The lack of real long-term concern has caused an alarming situation in many regions of some European countries that are undergoing a marked rural decline amid the changing composition of the population

* Corresponding author.
E-mail addresses: pilar.alonso@udl.cat (M.P. Alonso), pigarga@unizar.es (P. Gargallo), cle@unizar.es (C. López-Escolano), jamiguel@unizar.es (J. Miguel), salvador@unizar.es (M. Salvador).
[1] Member of the IEDIS (Instituto Universitario de Investigación en Empleo, Sociedad y Sostenibilidad).

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(Woods, 2005; Eurostat, 2022). In the debate about rural depopulation, policies that encourage the creation of new jobs are essential, together with the provision of basic facilities, services, and infrastructures that rural residents need to maintain a certain standard of living (Christiaanse, 2020). There are many tertiary activities, public and private (shops, pharmacies, financial institutions, schools, doctors, etc.), which have been closing down or reducing their services in rural areas due to the lack of dynamism provoked by the absence of job possibilities and labor replacement (Pinilla and Sáez, 2021). This accentuates the problems of these spaces, increasing territorial imbalances and the urban-rural gap (Higgs and Langford, 2013). The loss of services also feeds back into a greater deterioration of the development possibilities of rural spaces, since a minimum provision of activities and services is necessary for the stabilization or attraction of inhabitants (Vitale Brovarone and Cotella, 2020).

The issue of service provision in Europe's depopulated territories includes the emerging problem of financial exclusion. This is a complex issue, since financial exclusion is a multidimensional concept that can be defined in many ways. Sinclair (2001) defined it as "the inability to access basic financial services in an adequate way." However, there are a number of hidden factors behind this definition, such as citizens lacking the resources to access financial services; others related to financial institutions' policies towards their customers, marginalizing them by offering financial products that do not meet their needs; voluntary self-exclusion by customers, as they are unable to understand most banking services; or exclusions due to the lack of proximity to bank branches (Kempson and Whyley, 1999). In this paper, we focus on the latter, since it is affecting many rural areas that currently lack bank branches, which leads to greater problems in terms of the marginalization of the resident population (Fernandez-Olit et al., 2019). In fact, many people are forced to exclude themselves due to digital illiteracy, as they do not know how to use online banking, or because of their lack of understanding of how the banking sector works, or even because of mobility problems due to their advanced age (Llorente San Segundo, 2019).

The financial crisis that began in 2008 forced the banking system to undergo a profound transformation, causing a significant wave of mergers and takeovers between financial entities (Martin-Oliver, 2018). Furthermore, the economic impact of COVID-19 is causing banks to reduce their numbers of physical offices (Marcu, 2021; Higgs et al., 2022), leading to a complete restructuring of the financial sector through the closure of many branches and the loss of many employees to avoid spatial duplication. As Fernández-Olit et al. (2019) and De La Cuesta-González et al. (2021) point out, the reorganization of the bank network, carried out to increase their productivity, has worsened financial exclusion. This has seriously affected the employee-customer relationship because it implies a reduction of the time spent per user and a depersonalization of banking services. The closure of bank branches has, however, been accompanied by a strong digitization process that banks are undertaking, replacing their face-to-face services with the use of digital channels (Manta, 2022; De la Cuesta-González et al., 2021). As a result, a growing part of the population is encountering obstacles to access and use financial services (Leyshon et al., 2004; Anderloni et al., 2007; Gómez-Barroso and Marbán-Flores, 2013; Fernández-Olit et al., 2019), especially in rural areas where the provision of financial services is generally worse than in urban spaces (Argent and Rolley, 2000; Alloza et al., 2021; Camacho et al., 2021; Náñez-Alonso et al., 2022a). Specifically, quality internet access is a broad difference that exists between urban and many rural areas. The digital divide deprives many people who live in small and depopulated municipalities from the use of financial services (Jiménez-Gonzalo and Tejero-Sala, 2018). In addition, rural spaces have other financial needs that are different from urban areas, since many customers in these spaces require greater personal relationships and rely on trust systems with more fidelity between customers and companies (Demirguc-Kunt et al., 2017). But the differences are not only between the rural and urban world: Leyshon et al. (2004, 2008), Coppock (2013) and Náñez-Alonso et al. (2022a), among other authors, have shown that in Britain or Poland, rural areas have been unequally affected by the closure of bank branches, which suggests that the way to address this phenomenon might not be the same in all affected territories. In this sense, highlighting the phenomenon of financial exclusion caused by the scarcity of bank branches could be very helpful for decision-making in rural planning (Martin-Oliver, 2018; Náñez-Alonso et al., 2022a).

In this context, it is necessary to delve into the subject to obtain a better understanding of the relationship between financial exclusion and rural depopulation -manifested both in ageing and over-ageing, as well as in absence of job opportunities and the lack of labor dynamism). Against this backdrop, the main objective of this paper is to identify the existing patterns at the municipal level based on the degree of financial exclusion caused by the absence and scarcity of bank branches. This main objective is divided into two sub-objectives: 1) analyze how the sociodemographic characteristics of a municipality influence financial exclusion; 2) provide a typology of municipalities from the results obtained in the first sub-objective. This typology would be based on groups of municipalities with analogous sociodemographic patterns and similar availability of bank branches. Therefore, this classification could help policymakers to design measures of financial inclusion adjusted to the peculiarities of each territory in order to improve the well-being of its inhabitants. Notice that working at municipality level implies meticulous data disaggregation that reveals the heterogeneity existing in the rural world, which is not detected when working at higher levels (counties, provinces, regions).

In terms of financial exclusion, two types of discrimination caused by the absence or scarcity of branches could be distinguished. On the one hand, the exclusion caused by the absence of bank branches in a municipality, which we will call *Type I financial exclusion*. We suspect that this kind of exclusion may exist in very small, remote, and aged municipalities, whose inhabitants require bank tellers because they need help to obtain cash or to make payments and are unfamiliar with the use of new technologies. On the other hand, the financial exclusion caused by overburdened bank branches with an excessively high ratio of inhabitants assisted per branch, what we call *Type II financial exclusion*. We believe this may occur in larger municipalities where banks have closed many branches and those that remain are congested.

Although the decrease in bank branches has happened in most European countries, in Spain this process has occurred with greater intensity (Alonso et al., 2022). The Spanish banking sector, which had a very high number of small offices, has undergone a marked reorganization, forcing many closures and hastening the pace of digitization of banking activities. In 2008, at the beginning of the Great Recession, Spain had 45,662 bank branches. By 2022, their number had been reduced to 18,080, according to data from the Bank of Spain's Registry of Financial Institutions. This loss of offices has affected both urban and rural spaces. However, it is in the latter where the situation has become very worrying, since the number of branchless municipalities is increasing, something that not only does not help to solve the serious process of rural depopulation but even harms it. In 2012, 45.44% of Spanish municipalities did not have bank offices (Maudos, 2014), a figure that increased to 56.56% in 2022, according to the Bank of Spain.

Among all the Spanish regions, those located in the interior of the peninsula (except the Community of Madrid) are the most affected by regressive sociodemographic settings (Eurostat, 2022). This paper has focused on the case of Aragón, the second autonomous community by percentage of branchless municipalities (62%, more than 5 points above the Spanish average). Rural depopulation in Aragón has had a great impact, causing many areas to be considered "demographic deserts" due to their extremely low population density (Collantes and Pinilla, 2004). In addition, Aragón has an extreme ageing: almost 20% of its population is over 85 years old and 74% of its municipalities are overaged (Eurostat, 2022).

Even though Aragón alone does not explain the general situation in

rural Europe as a whole, it does present an interesting case study to understand the dynamics of financial exclusion and its relationships with the consequences of depopulation in rural areas for four reasons:

1) The strong and persistent process of depopulation in the region that has not yet stopped and that has left numerous municipalities in extreme situations of low demographic density (Ayuda et al., 2003).
2) Aragón is one of the most overaged regions in Spain and Europe, so the current rates of ageing in many municipalities cast doubt on their future demographic viability (Pinilla et al., 2008; Alonso-Logroño and López-Escolano, 2021).
3) The marked and progressive process of bank branch closures that has resulted in more than 60% of Aragonese municipalities not having bank branches (Alonso-Logroño and López-Escolano, 2021).
4) The existence of heterogeneity both in the processes of depopulation and financial exclusion. In Aragón, there are both depopulated and declining rural areas and dense and populated urban areas, hence the two types of financial exclusion described above could be present (Alonso et al., 2021; Alonso-Logroño and López-Escolano, 2021).

In short, Aragón exemplifies a situation that could occur, in the medium and long term, in other European regions with similar socio-demographic trends. In addition, the process of concentration and digitization of banking services is underway throughout Europe. Therefore, this study could be especially useful in rural regions of southern Europe long affected by demographic decline (Náñez-Alonso et al., 2022a; Panigyrakis et al., 2002), but also in other European sparsely-dense rural areas or those in demographic decline in the central and northern Europe (Carbó et al., 2007; Alessandrini et al., 2009; Horska et al., 2013; Kata et al., 2015; Ho and Berggren, 2020; Náñez-Alonso et al., 2022b). In Spain, it could also be useful for other autonomous communities, such as Extremadura, Castilla-León, Castilla-La Mancha, La Rioja, Asturias, or Galicia (Camacho et al., 2021; Alonso-Logroño et al., 2021; Alonso-Logroño and López-Escolano, 2021; Náñez-Alonso et al., 2022a). The methodology and results obtained in this paper might be applied to plan more suitable financial services for the territorial peculiarities of other European spaces.

To carry out this study, a statistical methodology adapted to the two sub-objectives specified above is used. Thus, with respect to the first sub-objective (analyze how the consequences of depopulation influence financial exclusion), we propose a regression model with panel data in two stages: a first step that analyzes, by means of a logistic regression, the factors that influence whether the municipality has or does not have a bank branch; a second step that uses a fixed-effect regression model to analyze the factors that influence the ratio of inhabitants per bank branch. These regressions will allow us to identify the factors related to depopulation (ageing, over-ageing, lack of job opportunities and labor dynamism) that determine type I and II financial exclusion, respectively. Regarding the second sub-objective (to provide a typology of municipalities), we apply cluster analysis techniques using the results obtained in the first sub-objective. Finally, the results are mapped to show territorial differences and contrasts that help identify problematic areas where specific policies could be applied.

In summary, the main contributions of the paper are threefold. Firstly, we provide a replicable statistical methodology to estimate the financial exclusion at municipal level, taking into account their socio-demographic characteristics, in order to construct typologies of municipalities based on these estimates. Secondly, based on the case study, we provide evidence at a very detailed level (municipalities) of how depopulation (understood in all its sociodemographic facets) leads banks to close or reduce their number of branches. Thirdly, we provide evidence of the existence of heterogeneity in Aragonese municipalities in terms of the type and degree of financial exclusion as well as their sociodemographic characteristics, which reinforce the design of inclusion policies that alleviate these problems based on the typologies identified.

The rest of the paper is organized as follows. Section 2 focuses on material and methods, so it presents the case study of Aragón, the variables involved, and the statistical methodology. Section 3 presents the results, while Section 4 discusses them. Finally, Section 5 concludes the paper with a brief summary and description of future research. We include one appendix where we show the mathematical expressions of the indicators used in the paper. Additional results are included in the supplementary material, which is available from the authors on request.

2. Materials and methods

2.1. Study area: Aragón

Aragón is a region of northeast Spain with a total area of 47,720 km^2 and, in 2021, it had a population of 1,314,586 inhabitants[2]; therefore, the average population density is very low (28 inhabitants per km^2). However, Aragón is characterized by its large demographic imbalances. It is a "top-heavy" region where 54% of the total population is concentrated in the municipality of Zaragoza, its political and administrative capital. However, the territory is dotted with many scarcely populated municipalities, although the mountainous areas of the Pyrenees and the Iberian Range are the most affected by depopulation (Fig. 1). More details on Aragonese demography can be found in the supplementary material.

These geographical disparities affect the economic and social development of these depopulated territories, such as the lack of proximity to basic education centers, health, culture, and social services, the existence of an unequal physical and digital communication network, insufficient transport services, difficulties accessing housing, and the risk of basic goods becoming scarce. All these issues aggravate the depopulation process and worsen the population's living conditions (Pinilla et al., 2008). For this reason, an analysis of the degree of financial exclusion is also necessary in order to identify the territorial inequalities that impact the inhabitants of depopulated municipalities compared to the inhabitants of more prosperous locations, if any answers to depopulation are to be offered. Quantifying the degree of financial exclusion of the different Aragonese municipalities will make it possible to establish a more precise spatial classification than that provided exclusively by demographic criteria.

The analysis carried out in this paper could be embedded in the Special Directive on Demographic Policy and Against Depopulation (Government of Aragon, 2017), issued by the regional government, which, in turn, is related to the Territorial Planning Strategy of Aragón (Government of Aragon, 2014). This strategy is based on a comprehensive model of balanced and sustainable territorial development for Aragón by the 2025 horizon. The goals of both documents indicate, among others, intervention in the lack of equipment and basic services, so as to reduce the existing gap between urban and rural supply.

2.2. Description of variables

In order to study the relationship between financial exclusion and depopulation in Aragón, we built a database with municipality data from different sources. Aragón has a heterogeneous demographic structure that requires a detailed analysis of a compendium of indicators at the municipal level to understand the phenomenon of depopulation and its consequences. Thus, to analyze the situation and the peculiarities of each municipality, we selected several indicators of demographic structure and of active population provided by the Aragonese Institute of Statistics at municipal scale. These indicators make it possible to determine the different realities with respect to their socioeconomic dynamism, which could be the cause of the financial exclusion in them. In order to analyze the presence or absence of financial exclusion in a

[2] Source: Aragonese Institute of Statistics (2022).

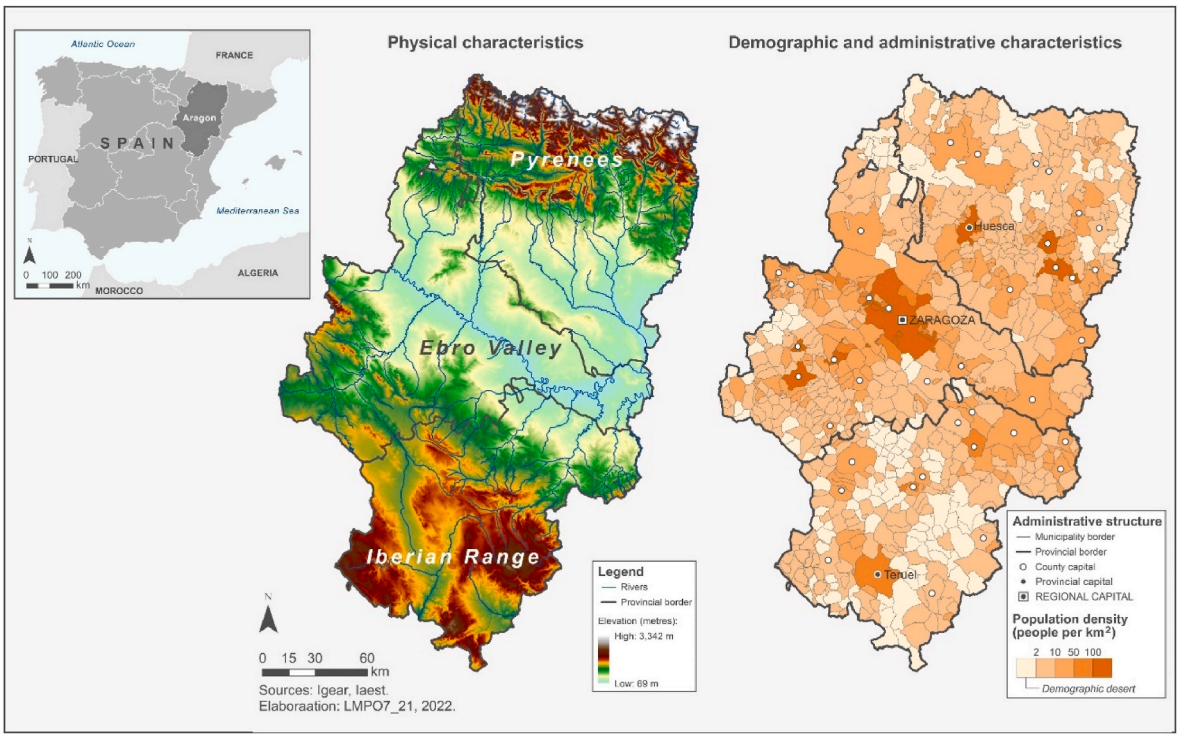

Fig. 1. Physical and demographic characteristics of Aragón.

municipality, we incorporated into the database information on the number of bank branches in it, obtained from the Bank of Spain's Registry of Financial Entities.

2.2.1. Sociodemographic variables

The following variables were selected to measure the degree of depopulation in each Aragonese municipality, whose definition can be seen in the Appendix. Thus, we selected the *Average Population Age* ($\overline{\text{Age}}$), which indirectly reflects the possibilities of dynamism of a municipality, because municipalities with a higher average age are small rural spaces lacking in dynamism, while municipalities with a lower age have dynamic demographic and socioeconomic features and correspond to urban and peri-urban settlements. Another variable closely related to the ageing of the population is the *Age Dependency Ratio* (ADR), which also has an economic significance, since it relates the inactive or economically dependent population to the potentially active population. In order to corroborate whether a high age dependency ratio corresponds to an older population and not a young population that is not yet of working age, we have selected the *Percentage of Population Older than 64* ($\%P > 64$). In addition, 65 years old is the most frequent retirement age, so this percentage also includes people who no longer have job opportunities. On the contrary, the *Youth Index* (I_{Youth}) shows the low number of young people in many rural spaces, which, in addition to ageing, reveals a lack of sufficient generational relief to ensure their sustainability. The *Masculinity Ratio* ($R_{Masculinity}$) also has significance in some demographic, socioeconomic, and territorial contexts. Thus, high values of this ratio in some municipalities reflect the scarcity of the female population, which, coupled with the generalized ageing of its population that has surpassed the childbearing age, constitutes one of the great weaknesses of the demographic structure of eminently rural municipalities. The *Percentage of Foreigners* ($\%P_{Foreign}$) is used, since low values in a municipality indicate that it is eminently rural with little provision of basic services and with less diversified economic and labor structures; this reduces its ability to attract immigrants. On the contrary, foreigners energize and rejuvenate the population. To complement the information on ageing processes, the *Over-ageing Index* ($I_{Over-ageing}$) was incorporated into our database, which reflects the effect of municipalities with a very elderly and less mobile population, therefore requiring greater proximity to complete daily tasks, such as going to a bank branch, and a greater dependence on other social services. For this reason, in Aragón, it is not the smallest municipalities that show the highest rates of over-ageing, but some larger municipalities that have health and care services oriented towards the elderly population. Finally, we were also interested in considering information related to both the job possibilities and the labor dynamism of a municipality, since these variables also encourage the presence of bank branches. To reflect this effect, both the *Affiliation Index* ($I_{Affiliation}$), the *Total Working Age Replacement Index* ($I_{Replacement}$), and the *Total Working Population Structure Index* ($I_{Structure}$) were used. This last index relates the youngest labor force to the oldest, and, therefore, it helps us to understand the implications that this may have on labor market and issues such as the entrepreneurial nature of the population or its ability to adopt innovations. All these indexes make it possible to distinguish municipalities characterized by a deep lag in their labor markets—incapable of offering alternatives, generating new economic activities, and attracting a younger and more dynamic active population—from demographically young municipalities that have, in many cases, a diversified and especially dynamic economic structure.

2.2.2. Bank branches

To study the degree of financial exclusion caused by the absence or paucity of bank branches, we used data from the Register of Branches of Supervised Entities, which includes a list of all branches supervised by the Bank of Spain, with quarterly information. Specifically, we took the data on the number of bank branches in each municipality every year from 2015 to 2021 (data for the month of December are taken as a reference). All this information was georeferenced at a municipal scale with the location of bank branches in the analyzed period, which also enabled us to reconstruct the path of office closures and better understand the logic of the spatial behavior of the financial system. From that information, we obtained two types of variables. First, a dichotomous indicator was used to signal whether a municipality has or does not have

a bank branch (0/1). Second, a continuous quantitative variable known as Saturation—calculated as the ratio of inhabitants per branch—was used for municipalities with at least one branch. This indicator has been widely used in literature as a proxy for both the quality of the bank offices' service and the degree of difficulty in the use of financial services (see Fernández-Olit, 2019; for review). Branches with high saturation are unable to offer high-quality, personalized service and have to reduce the time they spend with customers. Therefore, this indicator allows us to compare the degree of financial exclusion in different municipalities.

2.3. Methodology

In this section, we detail the methodology used to accomplish the two sub-objectives of the paper.

2.3.1. Sub-objective 1

Our data correspond to the 731 municipalities of Aragón with an observation period between 2015 and 2021, which provides us with balanced panel data. This meant we could use this double dimensionality to address the existing heterogeneity in the different Aragonese municipalities associated with their sociodemographic characteristics and with financial exclusion.

For this sub-objective, we analyzed the determinant sociodemographic factors of the financial exclusion caused by the closures of bank branches. To that aim, we applied a two-part panel data model. The first part of the model is a binary logistic regression, which determines the factors that influence the fact that a municipality does not have bank branches, that is, that it suffers from type I financial exclusion.

Mathematically, let (y_{it}, x_{it}; i = 1, …,N; t = 1, …,T) be the balanced panel data (in our case N = 731 and T = 7), where the dependent variable is $y_{it} = 1$ if the municipality i has no branches in time t, and $y_{it} = 0$ if the municipality i has branches in time t. The logit model is given by the following expression:

$$\text{logit}(P[y_{it}=1|\mathbf{x}_{it}]) = \log\left(\frac{P[y_{it}=1|\mathbf{x}_{it}]}{P[y_{it}=0|\mathbf{x}_{it}]}\right) = \boldsymbol{\beta}'\mathbf{x}_{it}$$

and its odds ratio, which quantifies the risk of a municipality i becoming a branchless one in time t, is given by:

$$\text{Odds\_Ratio}_{it} = \frac{P[y_{it}=1|\mathbf{x}_{it}]}{P[y_{it}=0|\mathbf{x}_{it}]} = \exp(\boldsymbol{\beta}'\mathbf{x}_{it})$$

The second part uses a panel data regression model with fixed effects to analyze the factors that influence the ratio of inhabitants per bank branch (Saturation). In this case, only the municipalities with at least one office are involved. High Saturation indicates that the municipality could be affected by type II financial exclusion.

Mathematically, let (Saturation_{it}, x_{it}; i = 1, …,M; t∈T_i) be the unbalanced panel data where $T_i = \{t\in\{1,\ldots,T\}: y_{i,t} = 0\}$ and M = cardinal $\{i\in\{1,\ldots,N\}: y_{i,1} + \ldots + y_{i,T} < T\}$; i.e., M is the number of municipalities that had branches in some of the analyzed periods.

The fixed-effects model was given by:

$$\log(\text{Saturation}_{it}) = \alpha_i + \mathbf{x}_{it}'\gamma + \varepsilon_{it} \text{ with } \varepsilon_{it} \sim N(0,\sigma_\varepsilon) \quad (1)$$

where the municipal fixed effects (α_i) are included to eliminate the estimation bias provoked by the omission of independent variables that varied across municipalities. Both models were estimated with the library *plm* of R.

2.3.2. Sub-objective 2

The second sub-objective is to obtain a classification of the municipalities based on the results obtained in sub-objective 1 for 2021. For this, we used cluster analysis techniques, conducting two classification processes. The first was carried out with the municipalities affected by type I financial exclusion using the information provided by the sociodemographic indicators. The second was conducted with the municipalities not affected by type I financial exclusion, but that could be affected by type II financial exclusion. In this case, we used estimates of the saturation of each municipality obtained from the panel regression model (1), which captures the systematic component of each saturation explained by the sociodemographic indicators.

Specifically, in each case, we first applied a hierarchical algorithm by using the Euclidean distance and Ward's method. To select the number of clusters, we used visual criteria like dendrograms or silhouette plots, and several numerical criteria provided by the *NbClust* function in R. Subsequently, we refined the solution using a k-means algorithm.

3. Results

This section presents the results obtained by applying the methodology described in Section 2.3. Section 3.1 presents the results of sub-objective 1 and Section 3.2 presents those of sub-objective 2. Both models were estimated using the R *blorr* and *plm* libraries, respectively.

3.1. Influence of sociodemographic characteristics on financial exclusion

Section 3.1.1 shows the results of the regression logistic model, which analyzes the determinant sociodemographic factors of the lack of bank branches. Section 3.1.2 shows the results of the panel data regression model (1), which studies the determinant sociodemographic factors of the saturation values.

3.1.1. Determinants of the lack of bank branches

The map in Fig. 2 shows the spatial distribution of the dichotomous indicator (0/1) of the availability of bank branches by municipality in 2021, in addition to incorporating the data for municipalities that had offices in 2015 but not in 2021. From this map, it can be seen that municipalities with low demographic density (Fig. 1) tend not to have branches, which confirms that less dense municipalities have a harder time keeping their bank branches. Moreover, the timeline graph in Fig. 2 shows the annual change in the percentage of branchless municipalities, highlighting a growing trend, accelerated above all by the banking restructuring in the pandemic period. Indeed, in 2021, 61.01% of municipalities were branchless.

Prior to estimating the logistic regression model, we carried out a dynamic exploratory analysis of the explanatory variables whose results are shown in the supplementary material.

3.1.1.1. Factor analysis. A multicollinearity problem was detected, and a factor analysis was performed in order to remove data redundancies in the explanatory variables. Four factors were identified, which accounted for 76.28% of the observed variation in the data. The first factor, labelled *Ageing,* is directly related to the Dependency Ratio, the Percentage of Population Older than 64 and the Average Age and inversely with the Youth Index. The second factor, labelled *Job Possibilities,* is directly related to Social Security Affiliation and the Working Population Structure and negatively with Masculinity. The third factor, labelled *Labor Dynamics,* is directly related to the Working Population Structure and the Replacement Index. Finally, the fourth factor is only directly related to the Overageing Index and, for this reason, it was labelled *Overageing*. These factors are weakly yet significantly related by solving the multicollinearity problem mentioned above (see supplementary material).

To visualize the territorial reality through the four factors, we mapped their factorial scores corresponding to 2021 in Fig. 3. Municipalities colored in dark gray are those with the lowest average age, the greatest job opportunities, the greatest labor dynamics, and the smallest over-aged population. On the contrary, municipalities in red have the largest over-aged population, with the greatest lack of labor dynamics. These latter spaces are found mostly in mountainous areas and their

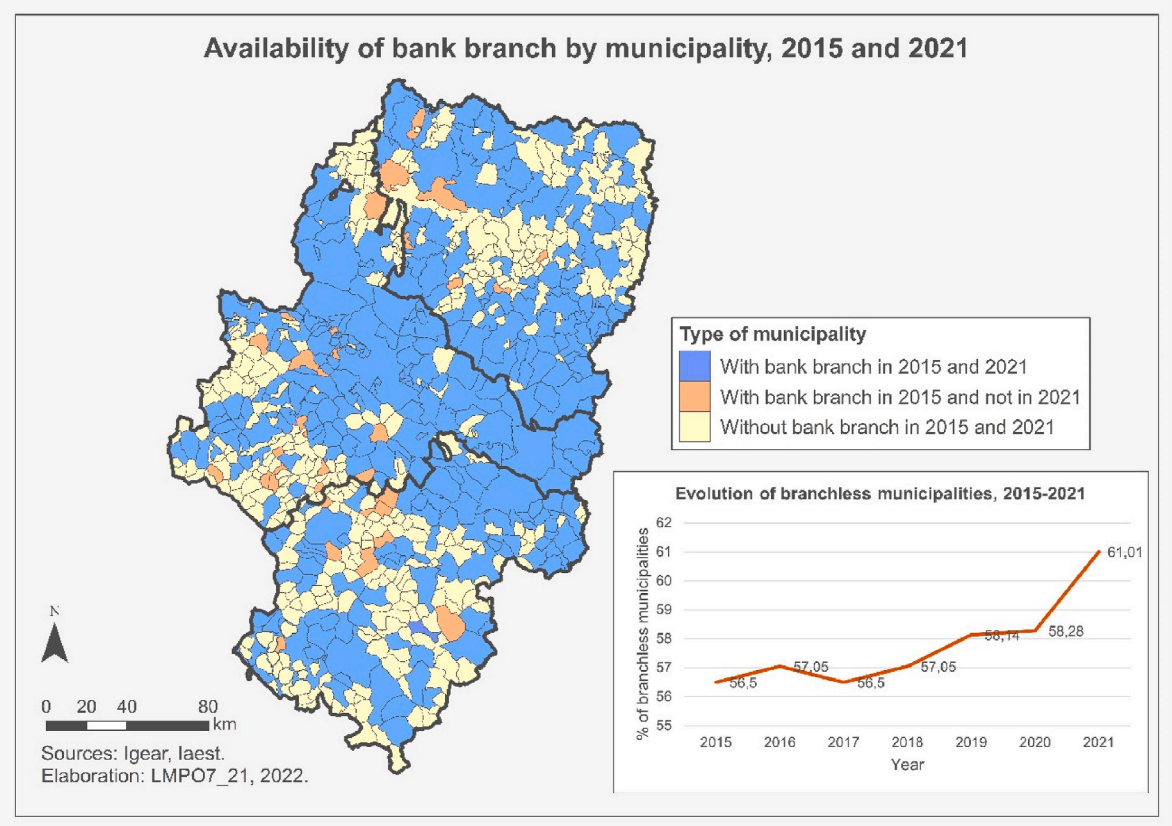

Fig. 2. Availability and branchless municipalities (%) evolution in period 2015–2021.

foothills. However, the highest mountain areas, which have been converted into places for tourist activities, have similar values to the Ebro Valley and the cities.

Finally, Fig. 4 shows the biplots of the factor scores, where branchless municipalities are shown in red, and municipalities with branches are shown in blue. Thus, panel A shows the biplot for the first two factors, and it is observed that the municipalities with branches are younger and have more job opportunities. Panel B displays the biplot of the first and third factor, and we can see that the municipalities with branches are also the ones with the greatest labor dynamics. Finally, the biplot of the first and fourth factor shows that the *Overageing* factor does not seem to discriminate between municipalities with branches from those that do not (Panel C).

3.1.1.2. Logistic regression results. Table 1 shows the results of the binary logistic regression analysis where the dependent variable indicates whether a municipality is bank branchless (Y = 1) or not (Y = 0) and the four previous factors are taken as independent variables. We also included dummy indicators for each year so as to capture the effects of the omission of time-related variables. We show the estimations of the odds ratios together with 95% confidence limits and the p-value of the significant test of each β coefficients for both the model that contains all the previous variables and for a simplified model, which contains only the significant variables. The goodness of fit of both models is appropriate with good predictive power, since the area under the ROC curve is 82.58% and R^2 coefficients have middle values (Table 2).

Analyzing the odds ratios in Table 1, it can be seen that the *Job Possibilities* factor and, to a lesser extent, the *Labor Dynamics* factor lower the risk of a municipality being left without bank branches, while the *Ageing* factor increases it. Furthermore, a significant risk increase can be seen in 2021, which revealed a generalized trend of banking entities leaving municipalities branchless.

3.1.2. Determinants of the saturation values

This section analyzes the influence of the previous four factors on the Saturation values. To that aim, we used the fixed-effects model for panel data (1). Prior to this estimation, we carried out a dynamic exploratory analysis of this variable.

3.1.2.1. Saturation variable. Fig. 5 shows the average value of the ratio of inhabitants per branch over time and highlights the strong increase in 2021. This trend had already been observed since 2018, but it accelerated during the pandemic, with some branches closing temporarily during lockdown that have yet to reopen and are likely to stay that way.

Fig. 6 shows two maps with a cartographic representation of the ratio of inhabitants per office at municipal level in 2015 and 2021. Branchless municipalities are represented in a light cream color, and those with the highest ratio appear in dark blue. A deep blue color is observed in Zaragoza, the Ebro corridor, and the biggest municipalities. The intervals selected for the cartographic representation—which must be wide to compare the two maps—together with the relatively short period analyzed (2015–2021) mean that the important spatial contrasts cannot be seen. However, some blue colors have intensified, showing the increase in the ratio in 2021 as more branches were closed. It must be borne in mind that the financial restructuring process and the closure of bank offices began in Aragón in 2008. These maps also show a certain relationship between the degree of financial exclusion and the size of the municipality's population.

3.1.2.2. Regression model with fixed effects. Since the maps in Fig. 6 revealed a certain relationship between financial exclusion and the size of the municipality, in the proposed model, we have also considered the

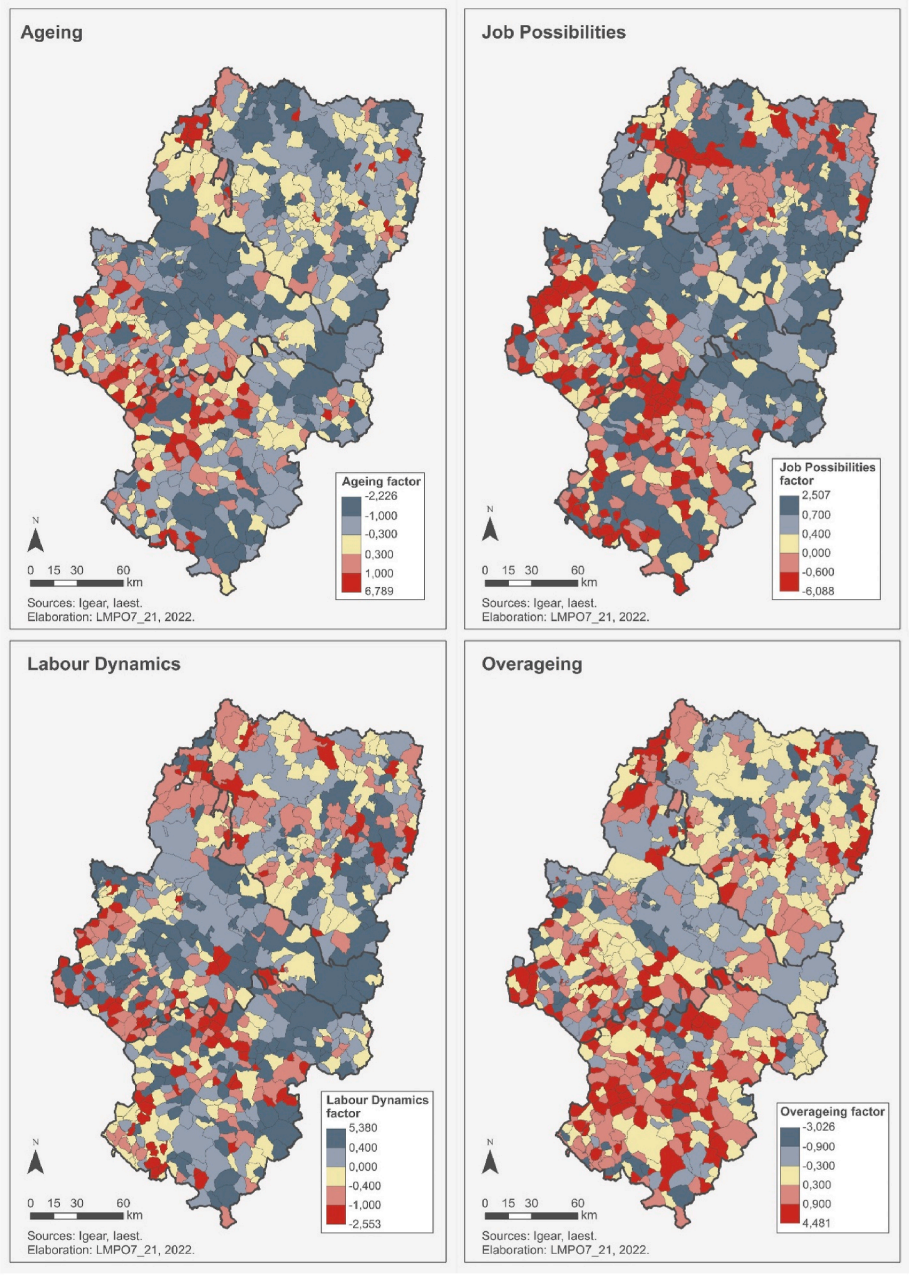

Fig. 3. Spatial distribution of the four factors' scores.

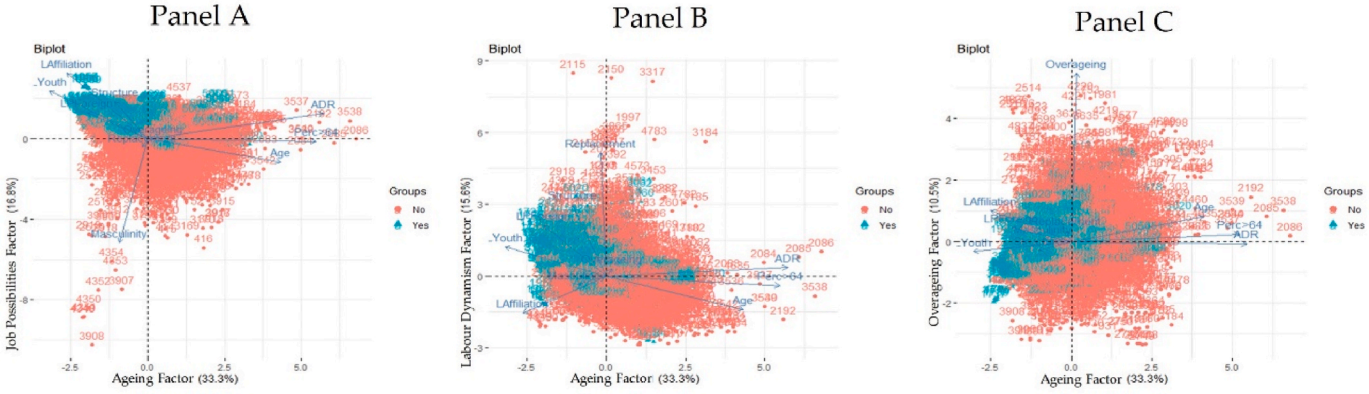

Fig. 4. Biplots of the factor scores distinguishing between branchless and non-branchless municipalities.

Table 1
Results of the estimation of the logistic regression models*.

	Odds Ratio	95% Inf	95% Sup	p-value	Odds Ratio	95% Inf	95% Sup	p-value
Ageing Factor	**1.7274**	**1.5865**	**1.8832**	**0.0000**	**1.7088**	**1.5731**	**1.8584**	**0.0000**
Job Possibilities Factor	**0.1967**	**0.1731**	**0.2227**	**0.0000**	**0.1964**	**0.1728**	**0.2225**	**0.0000**
Labour Dynamics Factor	**0.8024**	**0.7429**	**0.8668**	**0.0000**	**0.8033**	**0.7442**	**0.8672**	**0.0000**
Overageing Factor	0.9567	0.8840	1.0353	0.2713				
2016	1.0201	0.7951	1.3087	0.8756				
2017	0.9707	0.7558	1.2467	0.8164				
2018	0.9980	0.7759	1.2835	0.9874				
2019	1.0320	0.8006	1.3301	0.8074				
2020	1.0346	0.8025	1.3339	0.7922				
2021	1.2715	0.9855	1.6410	0.0565	**1.2456**	**1.0292**	**1.5090**	**0.0205**

*In red (blue) the odds ratios are significantly lower (larger) than 1. In dark (light) the 95% (90%) significant odds ratios.

Table 2
Goodness of logistic regression model fit.

CRITERIA							
General Model				General Model			
D de Soomers	0.6516	**AUC**	0.8258	**D de Soomers**	0.6514	**AUC**	0.8257
Deviance	5145.47	**Logllk**	−2572.73	**Deviance**	5146.96	**Logllk**	−2573.48
Pvalue	0.0000	**R2 MCFadden**	0.2590	**Pvalue**	0.0000	**R2 MCFadden**	0.2600
AIC	5167.47	**R2 Cox-Snell**	0.3000	**AIC**	5156.96	**R2 Cox-Snell**	0.3000
BIC	5239.41	**R2 Nagelkerke**	0.4030	**BIC**	5189.66	**R2 Nagelkerke**	0.4030

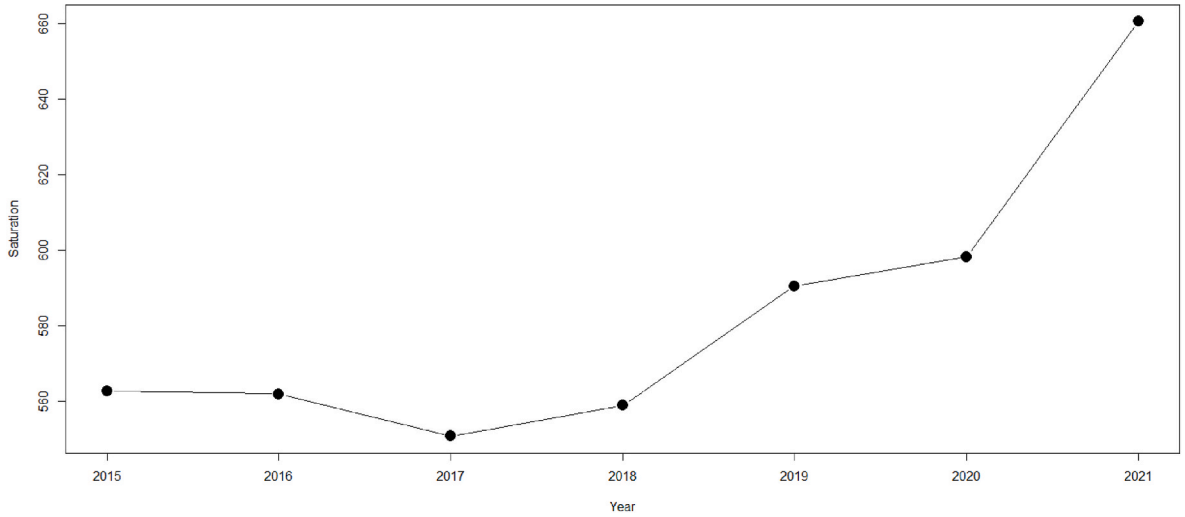

Fig. 5. Annual evolution of the Saturation average.

size of the municipality as an independent variable. Therefore, in the proposed model, the dependent variable is the logarithm of the saturation[3]; and the vector of independent variables, $\mathbf{x}_{it}$, includes a constant, the 4 factors *(Ageing, Job Possibilities*, *Labor Dynamics, Overageing)*, the discretized size municipalities (fewer than 100; between 101 and 500; between 501 and 1000; between 1001 and 2000; between 2001 and 10,000; more than 20,000 inhabitants), as well as time dummy variables. Table 3 shows the results of the estimation of the model together with those of the goodness of fit.

**In red (blue) the regression coefficients are significantly lower (higher) than 0. In dark (light) 95% (90%) significant coefficients.

The F-test rejects the null hypothesis of the non-significance of the model coefficients, while the pooling and Hausman tests show the existence of fixed effects in the model. It can be observed that *Labor Dynamics* is directly related to the ratio of inhabitants per bank branch

[3] We transform the saturation variable logarithmically in order to reduce the presence of outliers and increase the degree of normality of the dependent variable in the regression model.

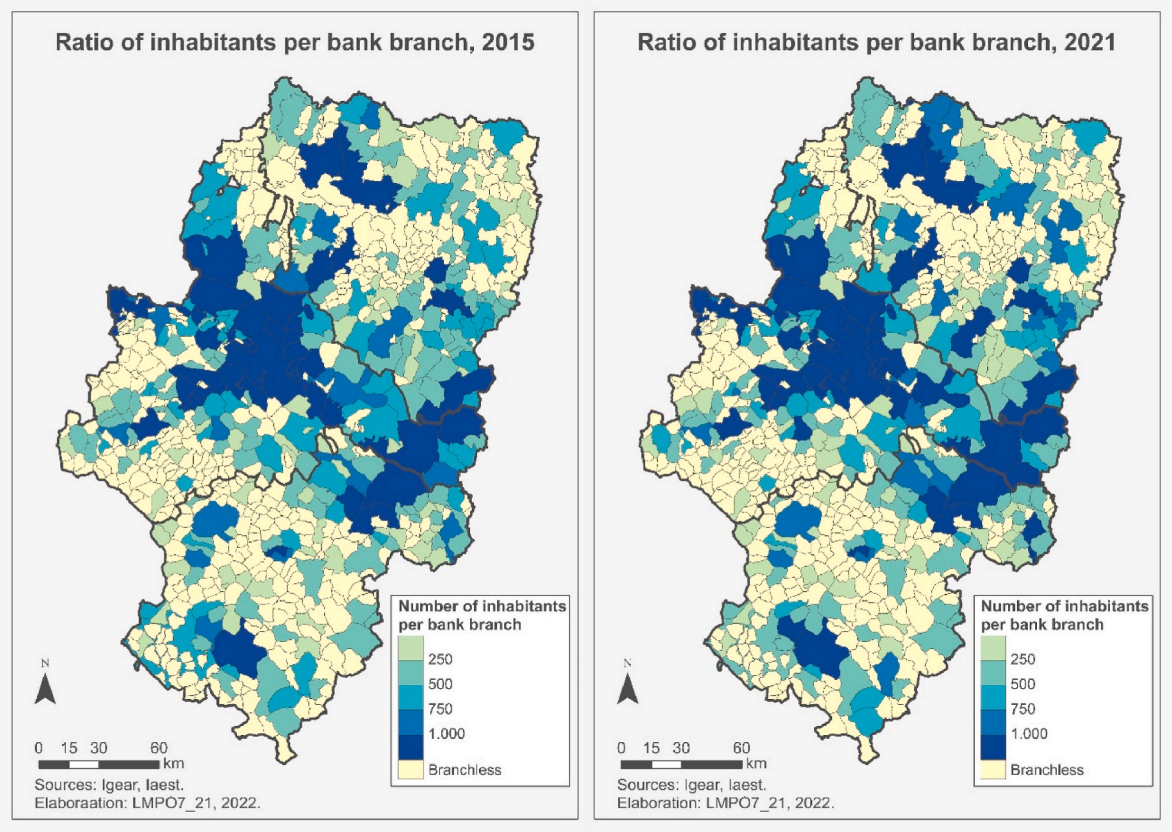

Fig. 6. Spatial distribution of Saturation in 2015 and 2021.

while *Over-ageing* and, to a lesser extent, *Ageing* are inversely related. In addition, there are significant positive year effects that began with the pandemic in 2020. These effects highlighted the downward trend in the number of bank branches mentioned above, starting in 2020 as a result of the COVID-19 pandemic. With respect to the municipality's population size, it can be observed that the larger the municipality, the higher the saturation, very probably due to the general tendency to reduce the number of branches, especially in large municipalities (Alonso et al., 2022).

3.2. Classification of municipalities

This section presents the results of sub-objective 2, that is, it shows a classification of municipalities that could help policymakers to design policies and measures tailored to each territory, taking into account both the degree of financial exclusion and its sociodemographic structure. The classification process takes place in two stages: Section 3.2.1 shows a classification of branchless municipalities based on their sociodemographic characteristics, and Section 3.2.2 presents a classification of municipalities with bank branches based on an estimate of their saturation obtained from the panel regression model (1).

3.2.1. Classification of branchless municipalities

To classify these kinds of municipalities, we applied the cluster analysis described in Section 2.3.2 by using the four sociodemographic underlying factors determined in Section 3.1.1 as grouping variables. The number of groups selected by the *Nbclust* function in R was three. The map in Fig. 7 shows the spatial location of the three groups, to which we have added, for comparison purposes, a fourth group made up of the municipalities that have branches. To analyze the internal validity of the identified municipality groups, Fig. 7 also presents five graphics with boxplots obtained by cross-referencing the four factors and the population size with the group variable.

In general terms, conglomerates B1 (100 municipalities), B2 (145 municipalities), and B3 (201 municipalities) tend to be sorted in increasing order by their population size and levels of job possibilities and labor dynamism, and in decreasing order by their level of ageing. Regarding the level of over-ageing, although it might be expected that the B1 municipalities—which have the most aged demographic structure and the least socioeconomic dynamism—would have the highest values, this is not the case and, in fact, they tend to have the lowest over-aged populations. Possibly the reason lies in the fact that these very small municipalities do not have health and care services that are so necessary for the most elderly individuals, corroborating what the Government of Aragón has indicated. The same does not occur with the rest of the groups, which follow the expected downward trend. Finally, it should be noted that the municipalities in B3 have very similar sociodemographic characteristics to those with bank branches but a smaller population size, which reduces their development potential.

3.2.2. Classification of municipalities with bank branches

To classify the municipalities with bank branches, we applied the cluster procedure described in Section 2.3.2, using as a grouping variable the estimated value of the logarithm of the ratio of inhabitants per branch in 2021, obtained with the panel data regression model (1). We identified four groups. The map in Fig. 8 shows the spatial location of the four groups, to which we have added, again for comparison purposes, a group made up of the branchless municipalities. To analyze the internal validity of the identified groups, we present six graphics with boxplots obtained by crossing the logarithm of saturation, the four factors, and the population sizes of the municipalities with the group variable.

In general terms, the clusters Group 1 (52 municipalities), Group 2 (96 municipalities), Group 3 (87 municipalities), and Group 4 (50 municipalities) tend to be sorted in increasing order by their levels of saturation, job opportunities, labor dynamism, and population size, and in decreasing order by their levels of ageing and over-ageing. The

Table 3
Results of the estimation of the panel data model*.

	Estimate	Std. Error	t-value
Ageing Factor	-0.0332	0.0189	0.0795
Job Possibilities Factor	-0.0297	0.0231	0.1981
Labour Dynamism Factor	0.0350	0.0093	0.0002
Overageing Factor	-0.0323	0.0099	0.0011
Year 2016	0.0138	0.0094	0.1451
Year 2017	-0.0188	0.0097	0.0529
Year 2018	-0.0083	0.0100	0.4054
Year 2019	0.0144	0.0104	0.1669
Year 2020	0.0203	0.0107	0.0576
Year 2021	0.0587	0.0111	0,0000
Between 101 and 500 inhabitants	0.1609	0.0671	0.0166
Between 501 and 1,000 inhabitants	0.1477	0.0723	0.0413
Between 1,001 and 2,000 inhabitants	0.1755	0.0805	0.0294
Between 2,001 and 10,000 inhabitants	0.1742	0.0936	0.0629
Between 10,001 and 20,000 inhabitants	0.2679	0.1348	0.0470
More than 20,000 inhabitants	0.2683	0.1661	0.1063
	Statistic	**Value**	**pvalue**
Goodness of fit	F	6.7698	0.0000
Pooling test	F	60.15	0.0000
Hausman test	Chi	378.95	0.0000

**In red (blue) the regression coefficients are significantly lower (larger) than 0. In dark (light) 95% (90%) significant coefficients.

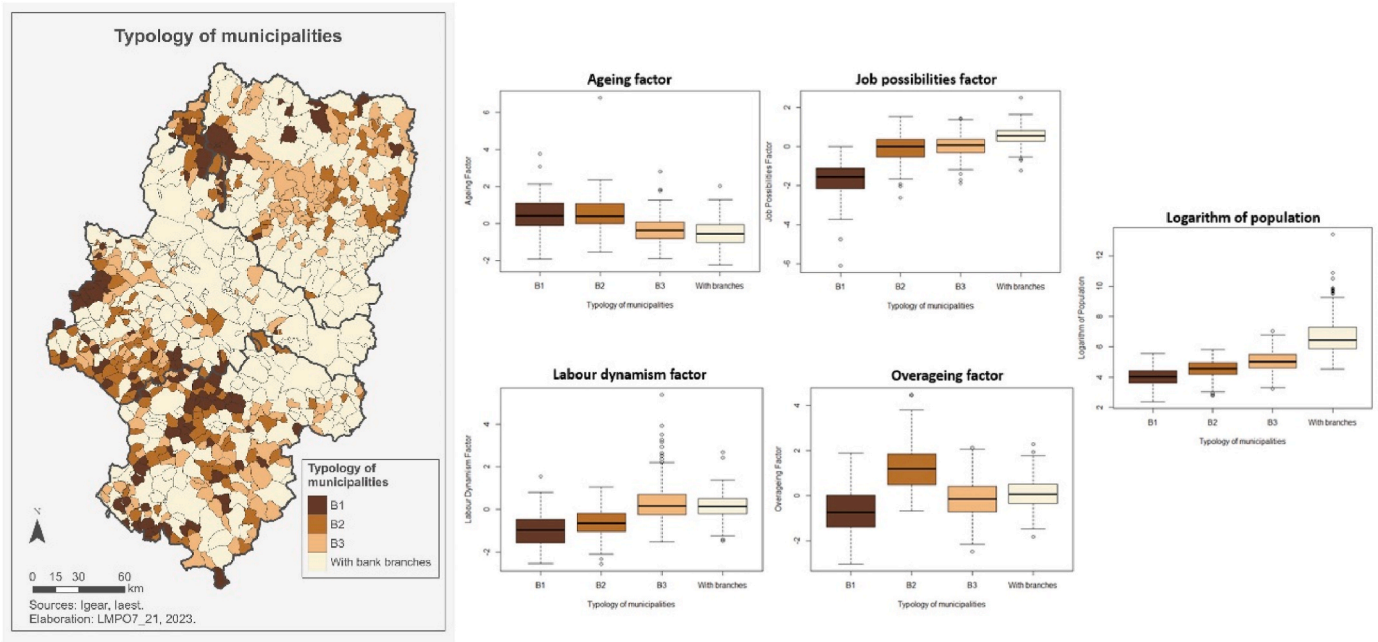

Fig. 7. Two-panel graphic with the results of the cluster analysis. Left panel: Spatial distribution of the groups. Right panel: Boxplots by groups for the four factors and the logarithm of population.

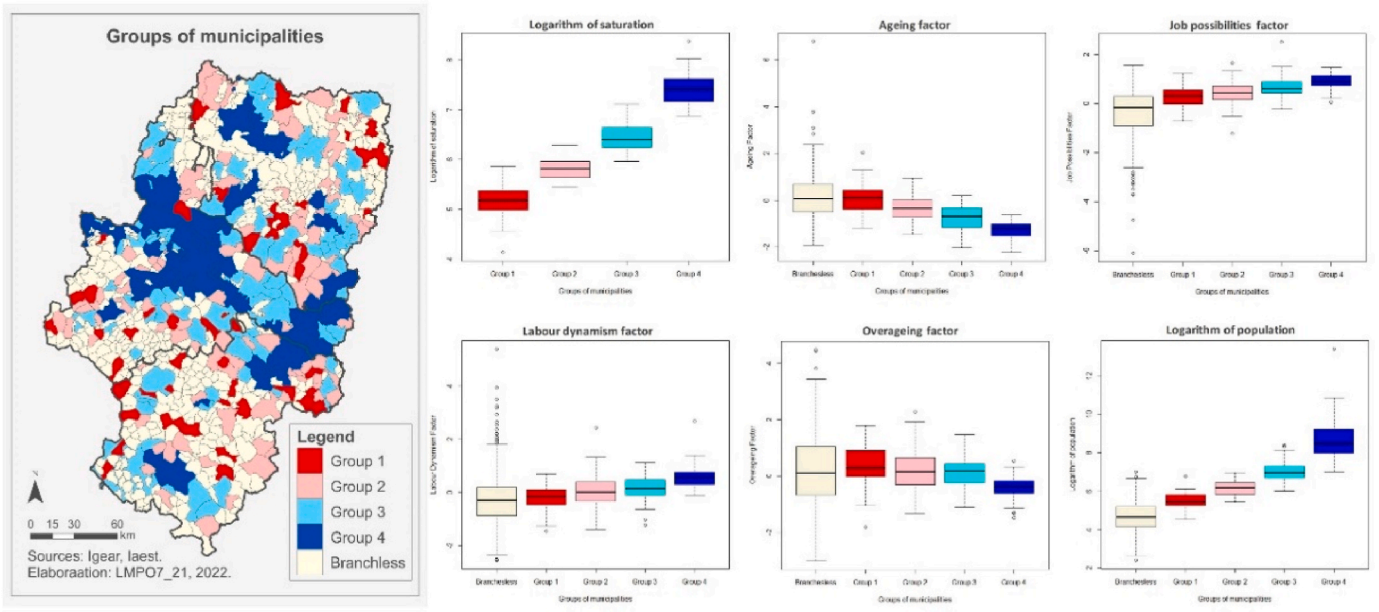

Fig. 8. Two-panel graphic with the results of the cluster analysis. Left panel: Spatial distribution of the groups. Right panel: Boxplots by groups for the logarithm of saturation, the four factors and the logarithm of population.

saturation levels of each group oscillated around 177 (Group 1), 334 (Group 2), 600 (Group 3), and 1290 (Group 4), with maximum values of 348, 534, 1229 and 4,334, respectively. If we compare these saturation values with those of other European countries, we have that according to the 2021 data from the European Central Bank, the value of the ratio of inhabitants per bank branch of Spain was 2563. Below are Bulgaria (1,845) and France (1,896), and immediately above are Austria (2,610), Italy (2,731) and Portugal (2,839). The rest of the European countries have ratios of more than 3000 inhabitants per branch. Therefore, our values demonstrate a general absence of overburdened bank branches in the Aragonese municipalities except in some in Group 4, where type II financial exclusion could exist. Group 4 includes the three province capitals, most of the county heads, and municipalities with a higher population density, located in the vicinity of Zaragoza, where a large part of the development hubs are located. Finally, analyzing the boxplots corresponding to the group without bank branches, great heterogeneity with respect to the rest of the groups is observed, which justifies the need to carry out the classification process shown in the previous section.

4. Discussion

Our findings have shown that ageing, the absence of job opportunities, and the lack of labor dynamism favor the existence of branchless municipalities. These results echo Martín-Oliver (2018) and De La Cuesta-González et al. (2021), who indicated that banks were disappearing from Spain's disadvantaged rural areas. They attributed this trend to the disappearance of savings banks, which specialized in relational banking and provided banking services to rural areas to prevent financial exclusion. After the global financial crisis of 2008, savings banks were forced to cease their social mission, underwent mergers and became banks to restructure the sector and manage the new financial situation.

Regarding municipalities with bank branches, labor dynamism and low levels of ageing and over-ageing favor an increase in saturation. This could be associated with the greater presence of younger, working-age people, probably with more digital skills that enable them to use online banking (Helsper and Van Deursen, 2015; Entorf and Hou, 2018). Therefore, these kinds of people would not need to go physically to bank branches, which might favor the reduction of the number of branches in the municipality. In addition, labor dynamism is directly related to the size of the municipality's population (see Fig. 8). Both facts favor an increase in saturation. On the other hand, the over-ageing municipalities tend to be smaller (see Fig. 8), and among their inhabitants are very elderly people who need personalized customer service, causing the bank branches to remain there, with a lower value of saturation as a result.

The finding that labor dynamism encourages the presence of overburdened bank branches seems to contradict with the results of Fernández-Olit et al. (2019), who found that more overburdened branches were located in districts characterized by a lower socioeconomic profile, indicating a banking industry trend towards "low-cost" retail banking to serve less profitable, more vulnerable customers. However, the contradiction is only apparent since these authors worked at district level and we worked at municipal level. A high saturation at municipal level does not necessarily imply that all its bank branches are overburdened and that all the districts are homogeneous in their socioeconomic profile, which may explain the discrepancies observed.

Our results also show the heterogeneity of the Aragonese municipalities with respect to their sociodemographic and financial situations. Therefore, the financial inclusion measures to be proposed do not necessarily have to be the same for all municipalities. It would not be profitable to open a bank branch in a municipality without a minimum critical mass to ensure its profitability. This reasoning justifies the development of the Strategic Protocol to Strengthen the Banking Sector's Social and Sustainable Commitment (CECA, 2021; AEB, 2021), where different solutions to favor financial inclusion in rural areas are proposed depending on the population size of the municipalities. It must be taken into account that the closure of bank branches is not the cause of depopulation, but rather its consequence, because when a municipality loses its economic and labor dynamism, its population dwindles, and services, both public and private, disappear. For this reason, public-private collaboration is essential, and the solutions should not come from the banking sector alone. Access to financial services (including cash) is also the public sector's responsibility (Náñez et al., 2022a).

Considering all these issues, Table 4 shows the proposed actions that, in our opinion, could be taken to increase financial inclusion in branchless municipalities, depending on the three typologies found. In B1 municipalities, which tend to have the oldest populations, and those

Table 4
Measures to increase financial inclusion in branchless municipalities.

Measures to achieve financial inclusion	Groups of branchless municipalities		
	B1	B2	B3
Financial and digital training		x	x
Improve internet connections		x	x
Mobile branch office bus	x	x	
Financial agent network		x	x
Banks & post office agreements	x		
Cashback and cash-in-shop, pharmacies		x	
ATMs			x
Shared banking hubs	x		
Community transport schemes	x		

with the least labor dynamism and job opportunities, but which tend to cluster geographically or to be close to municipalities with offices (see Fig. 7), it would be necessary to establish sharing banking hubs combined with community transport schemes that allow the ageing inhabitants to access bank services. Alternatively, mobile offices could be used, or the collaboration between banking entities and the public postal service could be strengthened. In this case, rural postmen could provide certain basic face-to-face financial services (receive and withdraw cash, etc.).

B3 municipalities, which are less aged due to the presence of younger and more dynamic populations, tend to be located near the economic development zones of Aragón. Therefore, a possible solution for this group would be to encourage the use of digital banking, providing financial and digital training to the residents of its municipalities, as well as improving internet connections. Another solution could be the installation of ATMs—operated by private banks in agreement with public authorities—for cash withdrawals, as well as creating networks of financial agents that make banking services more accessible without the need to open branches. These specific and entrepreneurial professional profiles would provide financial services in a collaboration model with a specific banking entity. When a branch closes due to the lack of economic viability for the bank, it leaves behind a portfolio of clients that an entrepreneur can take on, so that the entrepreneur, bank, and local population may benefit. The public authority could enable fiscal facilities for these types of professionals in selected geographical areas.

Something similar would have to be done in the B2 municipalities, but in this case, as they are less populated and more over-aged, their inhabitants could be served through mobile offices or access to cash in shops, supermarkets, or pharmacies through services such as cashback or cash-in-shop (Náñez-Alonso et al., 2020).

Regarding municipalities with bank branches, it is observed that, in general, there are no problems with overburdened branches that could be causing Type II financial exclusion, except in some Group 4 municipalities. In the Group 1 municipalities and, to a lesser extent, some Group 2 municipalities, our proposal would be to keep offices open to avoid the risks of Type I financial exclusion. It must be considered that many of these municipalities are located near branchless B1 and B2 municipalities, and therefore, their offices serve not only the municipalities themselves, but also the surrounding municipalities.

In our opinion, in the Group 3 municipalities (and in some Group 2) some offices could be eliminated, since these municipalities do not have high levels of saturation and ageing. Office closures do not have to imply financial exclusion. The important thing is to ensure reliable internet connections and that people have sufficient skills to use digital banking. For this reason, said elimination should be accompanied by the promotion of digital banking services and the improvement of the levels of financial and digital training of the population, as well as of high-speed internet connections. Perhaps bank foundations could finance or co-finance these actions that are normally funded by the public administration.

Type II financial exclusion issues could occur in the Group 4 municipalities, which include Aragón's three provincial capitals, most of the county seats, as well as municipalities in the Zaragoza metropolitan area. In the latter, the population has grown rapidly, which has caused a high level of saturation in their bank branches. So, in these places it would be necessary to limit the undesired impacts of these overburdened branches as much as possible, promoting, on the one hand, a better adaptation to the new digital environment, and on the other, improving the levels of customer service for the elderly. For this, it would be necessary to carry out an additional study at the branch level (in the case of smaller municipalities) or district level (in the case of larger municipalities) similar to that carried out in Fernandez-Olit et al. (2019) to detect, in more detail, which areas of the municipality could be affected by the problems of Type II financial exclusion caused by overburdened offices. This is outside the scope of the present paper, and its analysis will be addressed in future studies.

5. Conclusions

Depopulation is a problem faced by many European regions, and it has serious consequences for the continuation of socioeconomic activity. In addition, if we consider that in depopulated areas, the remaining population is very old, the problem is aggravated and leads to a vicious circle that is difficult to resolve. The population does not stay in these places because there are no opportunities, and they lack services to allow a quality of life similar to urban areas. Basic services are scarce or absent, as they are not profitable due to the lack of population. A growing number of regions are facing this situation, though the severity of the problems varies in different areas.

This work has focused on the relationship between rural depopulation and financial exclusion based on the absence of bank branches. We have provided a replicable statistical methodology to estimate the financial exclusion at municipal level, taking into account some sociodemographic characteristics related to depopulation, in order to build typologies of municipalities based on these estimates. Within this context, this paper has explored the case of Aragón (Spain), a European region with major problems of depopulation and over-ageing and with heterogeneous municipalities in terms of the type and degree of financial exclusion as well as their sociodemographic characteristics.

Our results have shown the need to consider the influence of the socio-demographic characteristics of the municipalities when explaining the phenomenon of the financial exclusion through the loss or absence of bank branches. Thus, a high degree of ageing, the lack of job opportunities and reduced labor dynamics are factors that increase the probability that a municipality will be branchless, and therefore, type I financial exclusion may occur. In addition to this general trend, the typology of branchless municipalities shows that there are municipalities with younger populations and certain job opportunities that are located near centers with greater dynamism. This contradicts our initial suspicions that this kind of exclusion exists only in very small, remote, and aged municipalities. This fact shows that measures taken to solve this type of exclusion must be tailored to the sociodemographic and territorial characteristics of the municipalities, since their banking access needs will presumably be different. With respect to municipalities with bank branches, larger and younger municipalities with higher dynamism and job opportunities present a higher ratio of inhabitants per branch, and type II financial exclusion may occur due to the low availability of bank branches. However, to delve into this type of exclusion, it would be necessary to work at the branch level, something that is outside the scope of this paper.

In addition to this limitation, the paper has only used indicators of demographic structure and active population. Although they may be proxies for the municipalities' socioeconomic situations, other types of variables could be incorporated, such as those related to the real estate market, the existence of services and their accessibility, the business and labor structure, educational level, etc. These factors could be relevant when determining typologies that better reflect the real situation of each municipality. Additionally, it would be appropriate to carry out surveys

of customers in the different groups of municipalities to accurately assess their needs and take more appropriate measures for each territory. All of this is on our future work agenda.

In this paper, we have focused on financial exclusion, but there are other kinds of exclusion that should be also considered. In this sense, we are currently working on the construction of a geographical exclusion indicator that, for a geographical area, can measure the inequalities suffered by inhabitants of the most depopulated and aged areas compared to the inhabitants of more prosperous locations. The results of this line of research will be presented elsewhere.

Author Contribution Form

M[a] Pilar Alonso: Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization. Pilar Gargallo: Conceptualization, Methodology / Study design, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition. Carlos López-Escolano: Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing, Visualization, Project administration. Jesús Miguel: Conceptualization, Validation, Writing – original draft, Writing – review & editing. Manuel Salvador: Conceptualization, Methodology / Study design, Software, Validation, Formal analysis, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization

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Data availability

The authors are unable or have chosen not to specify which data has been used.

APPENDIX A. (Expressions of the sociodemographic indicators)

Population is each municipality's number of inhabitants (P)

Age dependency ratio (ADR) is the ratio of dependents–people younger than 15 or older than 64–on the working-age population–those aged between 15 and 64. Data are shown as the proportion of dependents per 100 working-age people:

$$\mathrm{ADR} = \frac{P_{>64} + P_{<15}}{P_{15-64}} \text{ x100}$$

Percentage of population older than 64 ($\%P_{>64}$) is the population aged 65 and above as a percentage of the total population.

$$\%P_{>64} = \frac{P_{>64}}{P} \text{x100}$$

Average age of the population ($\overline{\mathrm{Age}}$) is calculated by adding all the ages of the people that make up that population, and dividing the sum by the number of those people.

$$\overline{\mathrm{Age}} = \frac{\sum_{i=0}^{\mathrm{maxage}} P_i x(i+0.5)}{P}$$

Youth index (IYouth) is defined as the ratio of people aged under 15 to people older than 64, expressed as a percentage.

$$I_{\mathrm{Youth}} = \frac{P_{<15}}{P_{>64}} \text{x100}$$

Masculinity rate ($R_{\mathrm{Masculinity}}$) is a demographic index that expresses the ratio of men to women in a given territory, expressed as a percentage.

$$R_{\mathrm{Masculinity}} = \frac{H}{M} \text{x100}$$

Percentage of foreign ($\%P_{\mathrm{Foreign}}$) is the foreign population as a percentage of the total population.

$$\%P_{\mathrm{Foreign}} = \frac{P_{\mathrm{Foreign}}}{P} \text{x100}$$

Overageing index ($I_{\mathrm{Overageing}}$) is defined as the ratio of very aged people (older than 84) to people older than 64, expressed as a percentage.

$$I_{\mathrm{Overageing}} = \frac{P_{>84}}{P_{>64}}$$

Index of affiliation ($I_{\mathrm{Affiliation}}$) is defined as the number of people affiliated to the Social Security system as a percentage of the total population.

$$I_{\mathrm{Affiliation}} = \frac{P_{\mathrm{Affiliated\ to\ SS}}}{P} \text{x100}$$

Total working age replacement index ($I_{\mathrm{Replacement}}$) is the ratio of working-age population aged between 16 and 19 to working-age population aged between 60 and 64, expressed as a percentage.

$$I_{\mathrm{Replacement}} = \frac{P_{16-19}}{P_{60-64}} \text{x100}$$

Total working population structure index ($I_{\mathrm{Structure}}$) is the ratio of working-age population aged between 16 and 39 to working-age population aged between 40 and 64, expressed as a percentage.

$$I_{Structure} = \frac{P_{16-39}}{P_{40-64}} x100$$

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jrurstud.2023.103105.

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