Received: 3 July 2022 | Revised: 21 October 2022 | Accepted: 12 November 2022

DOI: 10.1111/rsp3.12605

ORIGINAL ARTICLE

The spread of urban–rural areas and rural depopulation in central Spain

Juan Luis Santos[1] | María Teresa Fernández Fernández[2]

[1]Universidad CEU San Pablo, Spain

[2]Universidad Rey Juan Carlos, Spain

Correspondence
Juan Luis Santos, Universidad CEU San Pablo, Economics, Calle Julián Romea, 23, Office 1.20B, Madrid, ES 28003, Spain.
Email: juan.santosbartolome@ceu.es

Funding information
This research received funds from the European Commission through the ERASMUS + Project entitled "Population imbalances in Europe: Challenges of urban concentration versus rural depopulation" (SETTLE), grant number 620-414-EPP-1-2020-1-ES-EPPJMO-PROJECT.

Abstract

Europe faces serious demographic imbalances: increasingly, populations are concentrated in urban areas and their surroundings, while rural areas face depopulation. Thanks to a simple methodology identifying the trends in the different settlement structure, this article explores the causes that can justify the formation of such spatial trends through an econometric analysis. Both phenomena can be considered using central Spain as a case study. The area of more than 8 million inhabitants includes the city of Madrid and can be extended to other regions due to its simplicity and the wide availability of the included explanatory variables. This article categorizes nonurban areas into urban–rural and rural areas using a methodology that enables a historical perspective for the last eight decades. The findings are significant for infrastructure policies and territorial cohesion.

KEYWORDS
demographics, depopulation, peri-urban, suburb, transportation network

JEL CLASSIFICATION
J11, J18, R10

1 | INTRODUCTION

Most European countries face two issues related to the distribution of their population. First, rural areas in recent decades have faced depopulation. Simultaneously, the most populated cities and their surrounding areas are increasing in population density, exacerbating the imbalance, although the process has diminished recently (Dijkstra et al., 2013). This article has three aims: first, to study the historic evolution of rural depopulation and the increase in the urban–rural population (to this end, a novel methodology is proposed); second, to study the determinants that keep some areas rural while others become urban–rural; and third, to analyze the determinants of distinct rural depopulation in different areas.

This article describes a novel bottom-up methodology that avoids the dichotomy between rural and urban and overcomes the flaws of concepts such as peri-urban, suburban and sprawl (Brenner & Schmid, 2014). One of the first authors to highlight the increasing difficulty of defining city boundaries was Lefebvre (1970). Since then, numerous works have tried to identify and classify the demographic and socioeconomic processes that occur in cities' peripheries. There are three main theoretical frameworks with which to explore this topic (Obeso Muñiz, 2019):

The suburb can be defined as the area of urban periphery where socially homogeneous low-density residential land use prevails. The suburbanization process is of great importance in North America and is known as sprawl.

Rururban areas are disperse rural spaces that receive urban dwellers who change their traditional functions and building typologies (Bauer & Roux, 1976).

Peri-urban spaces are similarly characterised by discontinuity but also show heterogeneity in territorial uses and functions, maintenance of agricultural and farming activities, and high population mobility (Caruso, 2001).

The movement of urban populations to rural areas has several names according to its nature: suburbanization, counter-urbanization, de-urbanization, or ex-urbanization (Champion, 2001). These processes affect the landscape and how land is used (Nilsson et al., 2013). Therefore, these geographic processes are usually studied through changes in land use. However, this information is difficult to obtain, especially from a historic point of view. Thus, most studies are local or they have a low temporal scope.

Urban agglomeration and even metropolization are linked to the urban–rural process emergence: the growth of most populated cities and the depopulation of less accessible rural areas. The increase in agglomeration is related to productivity, which increases as a result of structural dynamics and changes in activities (Camagni et al., 2016). Urban areas play different roles affecting their surroundings, such as specialized marketplaces or high-level education faculties. In recent decades, there have been continuous changes in cities and their functions, impacting their surrounding areas (Capello et al., 2022).

The methodology is presented in Section 2 and tested in Section 3, using data from central Spain. The methodology facilitates a historical study starting in 1940, so the urban–rural expansion is analyzed since its origins. Section 4 determines the reasons some rural areas become urban–rural, applying logit models for each decade. Section 5 analyzes the determinants of changes in population in rural areas over the last 80 years. Finally, the conclusion summarizes the main findings, outlines their importance for public policy design, and suggests directions for future research.

2 | METHODOLOGY

This section describes the proposed methodology, which makes it possible to study urban, rural, and urban–rural populations from a historic perspective.

Six international organizations—the European Commission (Eurostat and DG for Regional and Urban Policy), the International Labor Organization, the Food and Agriculture Organization, the Organization for Economic Cooperation and Development, United Nations Habitat, and the World Bank—define cities as areas with a population of at least 50,000 inhabitants in contiguous dense grid cells (2020). According to the degree of urbanization, land is classified into cities, rural areas, and a third group of towns and semi-dense areas. This approach is recommended for studying a population's spatial distribution. There are no population grids available for the past, so studying how this third

type, neither rural nor urban, emerged and evolved is unfeasible. The presented approach is conceived to be as similar as possible but acknowledges that using municipalities instead of a grid is necessary to attain a historical perspective on the topic due to the lack of population grids.

The urban–rural dichotomy does not adequately represent current population patterns of settlements, necessitating at least a third category in between with distinct characteristics. Areas that are neither urban nor rural are usually in the vicinity of urban settlements; however that is not an essential characteristic, so peri-urban is not the most appropriate concept. Urban–rural, on the other hand, establishes that this third classification shares some urban characteristics as well as some rural ones. Urban–rural can be seen as equivalent to the third category presented in the report by the International Labor Organization, the Food and Agriculture Organization, the Organization for Economic Cooperation and Development, United Nations Habitat, European Commission and the World Bank.

If a population is equal to or exceeds 50,000, the local units are defined as urban. If the municipality was urban but the population decreases below this threshold, it is defined as declining urban. Conversely, if the population has doubled from the minimum in recent decades and in one decade it increased by at least 20%, it is defined as urban–rural. The term *urban–rural* is preferred to peri-urban, rururban, or suburban because it can be any of these three; a socioeconomic study would be required to determine the exact nature of each of the areas identified as neither rural nor urban. This name is used to overcome the multiple definitions aiming to capture the different realities of the areas that are no longer rural but are still not part of a city (Taylor & Lang, 2004).

If the municipality is not urban, declining urban, or urban–rural, it is considered rural. All local units start as rural. They can turn into urban areas directly or urban–rural areas depending on the intensity of their growth. Urban–rural local units can also become urban if they keep growing and surpass the threshold of 50,000 inhabitants. Finally, urban local units cannot return to rural or urban–rural under the proposed approach, but they can be considered declining urban: an urban environment where the population decreases.

This simple classification heuristic is powerful enough to facilitate the implementation of a historical analysis of rural depopulation and study why rural local units become urban–rural. These possibilities are illustrated in Section 3 using data from the central part of Spain, which includes the urban agglomeration of Madrid.

Once the land is classified as either urban, rural, or urban–rural, the determinants of population change and rural areas becoming urban–rural can be studied, as can the factors that have contributed to these changes in the last few decades. Data for the determinants included in a study with a historical point of view need to be available for the whole period considered and the spatial disaggregation needs to be at the local unit level. That constrains the variables to be used. Digitization, though it has been a major force for population relocation in recent times, cannot be quantified at a local level with the available information. Economic activity measured with data from labor or company variables starts recently in most countries. It has been proved for the area under study that urban–rural local units have a statistically significant higher weight of industry and services than rural areas and less primary activities, while urban areas have a higher weight of industry and primary activities and a lower importance of services.

The variables included in the analysis need to be available at a local level from the period prior to the emergence of the urban–rural phenomenon. They are as follows.

- Distance to the capital, measured in kilometers. This variable is included in most of the studies that address peri-urbanization and metropolization processes (Follmann et al., 2022). The effect of cities on their surrounding areas has increased and enlarged in spatial scope since the democratization of cars and the appearance of high-capacity roads (Ravetz et al., 2013).
- Population in the previous census. The change in population depends to a great extent on the population at the beginning of the period. Most historical studies find that small local units tend to shrink, while the most populated settlements experience the greatest population growth (Firmino Costa da Silva et al., 2017; Le Gallo & Chasco, 2008).
- Access to nearby high-capacity roads is a well-studied spatial characteristic that impacts on population growth positively (Jacobs-Crisioni & Koomen, 2017). The accessibility and degree of connection with the main centers of

population and economic activity is key to rural growth and the appearance of urban–rural areas. This effect started in developed countries and is now extending to developing ones (Khanani et al., 2021), and it is linked with changes in employment (Redfearn, 2009).

- Peri-urban municipality is included as well to study the effect of being in the vicinity of urban local areas. It captures the peri-urbanization process, while distance to the capital, which could be any important city in the area under study, measures the spatial extent of the effect.
- Altitude is a variable that also affects population change in the last few decades (Ayuda et al., 2010), and it is included to verify whether the effect continues or diminishes as found for some areas as a result of improved accessibility (Portnov et al., 2011).
- Irrigated agriculture and reservoirs are, in addition to transport infrastructure, the most important territorial cohesion policies implemented in the area under study in the last few decades. The analysis allows study of their effects on rural areas affected by infrastructures built by the public sector with the aim of maintaining population within the territory and increasing economic growth in the surrounding areas.

3 | URBAN–RURAL CHANGES THE PICTURE

To verify the relevance and usefulness of the methodology presented in this article's introduction, we examine a region comprising six Spanish provinces, which is currently home to more than 8 million inhabitants and consists of 1,356 municipalities. This region is roughly hexagonal in shape, spanning 386 kilometers from east to west and 214 kilometers from north to south, with the country's capital, Madrid, roughly in the center.

Madrid and its surrounding provinces constitute an interesting and relevant case study. Madrid is the sixth most populous municipality in Europe after Istanbul, Moscow, London, Saint Petersburg, and Berlin. In the case of taking the European urban agglomerations according to the Organization for Economic Cooperation and Development's methodology (2012), it is the fourth largest European agglomeration after Istanbul, Paris, and London. The results presented below could be extrapolated to apply to any large European city since the process of peri-urbanization is not unique to Spain but rather a global phenomenon taking place the recent decades.

One of the greatest advantages of the methodology used, apart from its simplicity, is that it only requires census information at the municipal level, which means a historical analysis is feasible without needing grid maps that collect the population density. According to studies that address peri-urbanization and the growth of urban agglomerations in Spain (Ayuda et al., 2010), the most likely periods for the origin of this processes are the 1950s or 1960s. For this reason, the analysis begins before the emergence of the urban–rural population.

As can be seen in Table 1, no urban–rural municipality is found until the 1950s, when 10 appeared close to the capital and with two different typologies: nine local units were rural areas that grew due to the presence of new industrial zones requiring workers and were accompanied by the construction of housing blocks. The remaining one, Guadarrama, located in the mountain range to the northwest of the capital (see Figure 1), increased its population due to the creation of private urbanizations of single-family homes for the capital's wealthy class, and it was be the first case of sprawl in the studied area. In the 1950s, the phenomena of peri-urbanization and suburbanization were still incipient in the area studied and only affected 1.4% of the population. In this decade, the capital continued to grow as it had been doing previously, and its population grew from 40.6% to 54.2% of the total population.

The urban–rural phenomenon extended during the 1960s and encompassed 31 municipalities with six times the population living in this type of areas compared to ten years prior (6.1% of the region's total). Some municipalities near the city of Madrid reached 50,000 inhabitants and are therefore considered urban, while a growing number changed from rural to urban–rural, following the differences found in the previous decade: the predominance of single-family homes and sprawl in the west, and blocks of flats and industrial areas in the rest of the periphery (Vorms, 2017). Already at this early date this transformation of rural areas exceeded the administrative limits of the province of Madrid and three urban–rural local units were in Toledo: in two of them agri-food industrial areas were

TABLE 1 Evolution of population by typology of local unit

Year	1940	1950	1960	1970	1981	1991	2001	2011	2021
Urban municipalities	1	1	1	4	15	16	20	27	29
Urban population	1,102,933	1,553,338	2,177,123	3,303,970	4,430,216	4,459,617	4,906,588	5,923,936	6,288,236
	38,8%	46,0%	54,2%	65,9%	75,7%	74,2%	73,8%	74,7%	76,2%
Urban–rural municipalities	0	0	10	31	42	69	123	193	191
Urban–rural population	0	0	57,001	307,980	324,416	512,770	774,638	1,241,389	1,274,915
	0,0%	0,0%	1,4%	6,1%	5,5%	8,5%	11,7%	15,7%	15,4%
Rural municipalities	1,355	1,355	1,345	1,321	1,299	1,271	1,213	1,136	1,136
Rural population	1,739,524	1,824,357	1,785,353	1,402,603	1,099,402	1,035,787	967,774	761,860	689,276
	61,2%	54,0%	44,4%	28,0%	18,8%	17,2%	14,6%	9,6%	8,4%
Nonurban population	1,739,524	1,824,357	1,842,354	1,710,583	1,423,818	1,548,557	1,742,412	2,003,249	1,964,191
Total population	2,842,457	3,377,695	4,019,477	5,014,553	5,854,034	6,008,174	6,649,000	7,927,185	8,252,427

Source: Authors' elaboration of population census data (ine.es).

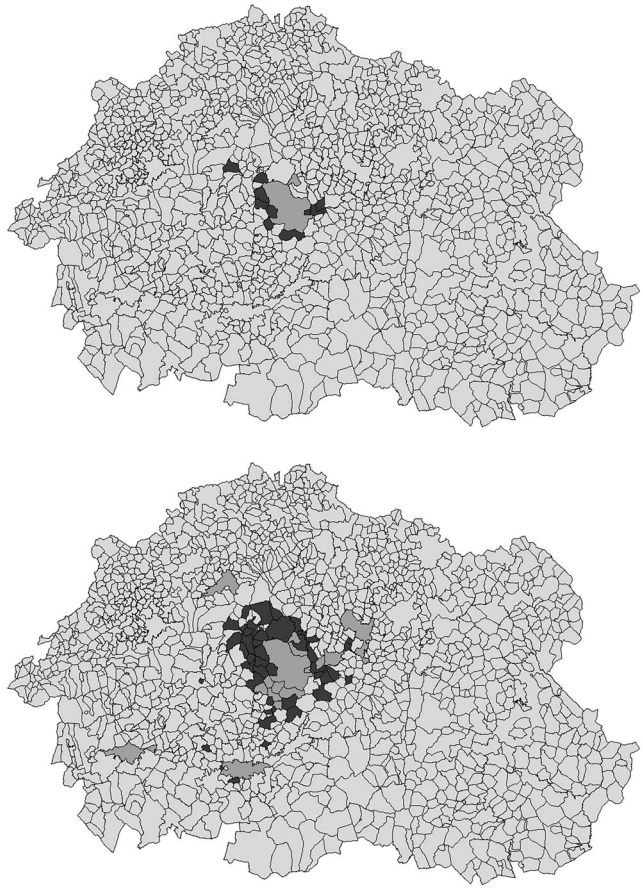

FIGURE 1 Classification of local units in 1960 (up) and 1981 (down). *Note*: Rural areas in light gray, urban areas in medium gray, urban–rural in dark gray. *Source*: Authors' elaboration of population census data (ine.es)

developed and in the remaining, Cobeja, several quarries as well as industrial plants to produce ceramics were built during that decade. This verifies how the proposed methodology allows us to correctly identify rural areas that experience significant transformation processes that cannot be explained by natural population growth.

During the 1970s, several municipalities in the south and east near Madrid that were previously urban–rural and grew as industrial zones populated with workers migrating from other Spanish regions exceeded the limit that allowed them to be classified as urban. Four nearby administrative capitals also reached this figure (see Figure 1), and the urban–rural phenomenon continued to grow by extension; however, due to the complete urbanization of some local units, the population hardly increased under this categorization and in fact decreased from 6.1% to 5.5%. As the map shows, there are two urban–rural municipalities bordering Toledo, in the south of the region, so this process is not specific to a large city but rather started to occur in the vicinity of smaller cities.

The presence of urban–rural areas continued in the following decades and by 2001, 123 municipalities and 11.7% of the population were included in this classification. As shown in Figure 2, the urban–rural area included a circle surrounding Madrid and nearby urban municipalities. There are also some municipalities that are neither urban nor rural close to the four cities near the capital (Guadalajara, Segovia, Talavera de la Reina, and Toledo). Likewise, it is observed in the eastern part of the region how one new urban–rural municipality borders the administrative capital (Cuenca). This regional capital had not attained a sufficient population to be considered urban by 2001. Furthermore, its growth was very slow. Therefore, the methodology implemented does not classify it as urban–rural. In fact, as

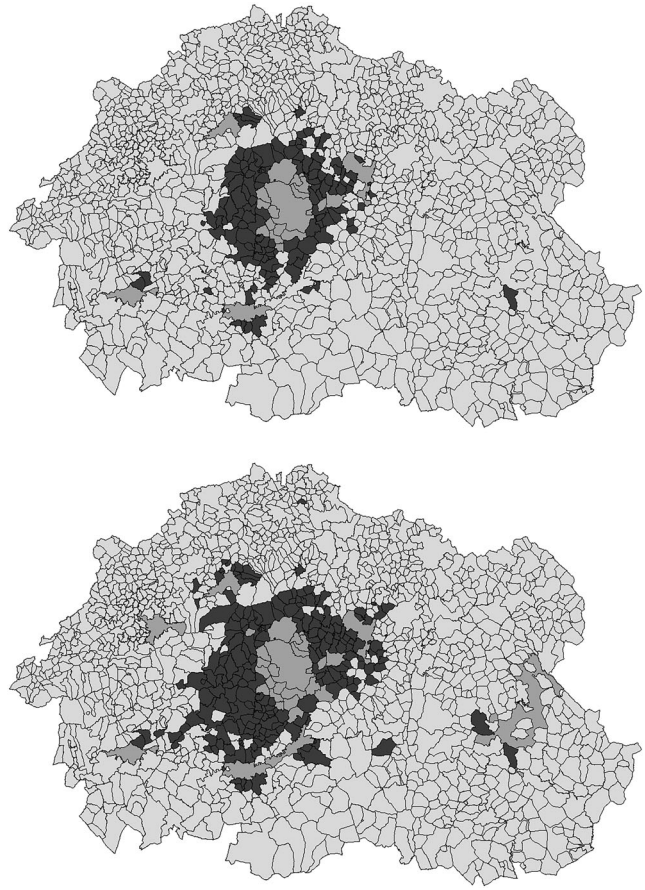

FIGURE 2 Classification of local units in 2001 (up) and 2021 (down). *Note*: Rural areas in light gray, urban areas in medium gray, urban–rural in dark gray. *Source*: Authors' elaboration of population census data (ine.es)

part of a peripheral region, it had net emigration during this period (Viñuela & Fernández-Vázquez, 2012), which, together with its small size, does not allow it to be considered either urban or urban–rural despite its administrative status.

The first decade of the twenty-first century saw the greatest expansion of the urban–rural population of the area studied; it grew by almost half a million inhabitants or from 11.7% to 15.7% of the total. The intense real estate bubble made it difficult for new households to access housing, so they moved both to the already established periphery and to predominantly rural municipalities that were even further away from the capital (Pozo Rivera & Rodríguez Moya, 2006). The economic crisis and the population stagnation of the recent decade stopped the process, and it is only two urban–rural municipalities reached the 50,000 inhabitants threshold to be classified as urban. There were practically no changes in the classification of municipalities or in the weights of each of the three population classifications. Thus, it can be deduced that the processes of urbanization and urban–ruralization are mainly due to population growth and economic factors (Martori, 2010).

The inclusion of the urban–rural category is extremely important not only in itself but also to correctly study the historical evolution of rural areas. The lower part of Table 1 includes the sum of the population of rural and urban–rural municipalities, which ranges between 1.4 and 2.0 million in the last eight decades and is currently at its maximum. However, taking only rural municipalities shows that this is not the case; since 1950 (1.8 million) rural depopulation has been very intense and currently there are 689,000 inhabitants. Even though the number of rural

municipalities has fallen from 1,355 to 1,136, this decrease would hardly explain the intense depopulation experienced in the period and which continues nowadays. Rural population decreased sharply from 61.2% eight decades ago to only 8.4% currently. If the concept of urban–rural is not correctly characterized, it is impossible to analyze the magnitude of depopulation in the rural environment, a process that is especially worrying in Spain but that occurs in the vast majority of developed countries.

4 | FROM RURAL TO URBAN–RURAL: A HISTORICAL PERSPECTIVE OF THE PROCESS

After describing historical process of the increase in the urban population, particularly the emergence and explosion of the population in local urban–rural units, this section aims to discover the determinants of the transformation from rural to urban–rural areas in each decade and check whether these factors stayed the same over time or changed, as well as the magnitude of each factor's impact.

For this, a categorical variable was created that takes the unit value for urban–rural municipalities and is zero for rural areas. Urban municipalities were excluded from the analysis. Appropriate tests (Davidson & MacKinnon, 1984) verified that the use of logit models is the more appropriate than probit, ordinary least squares, and panel models with a categorical dependent variable (Arellano, 1993). In this case, this is due to the high variability between decades and the low number of periods.

Four variables were considered that could explain why some rural municipalities remain rural while others become urban–rural:

1. Distance to the capital of the urban agglomeration, in this case Madrid, measured in kilometers. It is a Euclidean distance due to the impossibility of knowing with certainty the temporal distance throughout the period due to the great changes in the transport network. A negative effect of this variable was hypothesized: the greater the distance, the lower the probability that the municipality is urban–rural. The maximum of this variable was 207 kilometers, and the mean was 94.6.
2. Population at the beginning of the decade measured in thousands of inhabitants. Although the municipalities can be urban–rural with any size population, it was expected that a high proportion of them started with a larger population.
3. Nearby highway. Spain's main road network has hardly changed since the mid-nineteenth century, although it has been progressively improved. Therefore, it was not necessary to introduce changes in this variable over time. If the municipality is less than five kilometers from one of these communication routes, the variable took the unit value (548 municipalities, 40.4%) and zero otherwise (808 municipalities, 59.6%). It has been verified that changing this limit to figures between two and ten kilometers keeps a similar effect and significance. The distance to the nearest highway was not included due to the high correlation of that variable with the distance to the capital since Madrid plays a main role in the transport network.
4. Peri-urban municipality: A dichotomous variable was created for each decade. The unit value was assigned to neighboring municipalities to at least one urban municipality and zero otherwise.

Table 2 presents the results obtained from the logit models in each decade. As expected, the distance to the capital is always significant and decreases the probability that the municipality is urban–rural. A larger population increases the likelihood that the municipality is not rural, but this variable is not significant in every decade; the largest municipalities are urban–rural to a greater extent during the period 1960–1981 and again in the last two decades.

The existence of first-level road transport infrastructure is positive in the last three decades but is insignificant beforehand. In the first decade studied, this variable cannot be included since all the urban–rural municipalities have a unit value and therefore there is collinearity. Something similar happens with the peri-urban municipality variable,

TABLE 2 Logistic regressions for urban–rural versus rural local units by decade

Variable	1950–1960	1960–1970	1970–1981	1981–1991	1991–2001	2001–2011	2011–2021
Distance to capital	−0.189 *** (0.048)	−0.121 *** (0.020)	−0.102 *** (0.016)	−0.116 *** (0.015)	−0.083 *** (0.008)	−0.079 *** (0.006)	−0.073 *** (0.006)
Population in the previous census	0.023 (0.123)	0.106 ** (0.039)	0.115 * (0.057)	0.068 (0.047)	0.024 (0.037)	0.192 ** (0.058)	0.268 *** (0.048)
Near highway		1.840 (1.060)	0.077 (0.480)	0.042 (0.386)	0.616 * (0.280)	0.832 ** (0.242)	0.726 ** (0.249)
Peri-urban municipality			0.238 (0.466)	0.812 * (0.415)	1.231 *** (0.322)	0.612 * (0.300)	0.507 (0.314)
Constant	1.452 (1.009)	−0.144 (1.217)	1.406 (0.728)	2.696 *** (0.651)	2.217 *** (0.446)	2.767 *** (0.414)	2.209 *** (0.425)
No. of observations pseudo R^2	1,355 (0.556)	1,352 (0.570)	1,341 (0.513)	1,340 (0.589)	1,336 (0.536)	1,329 (0.566)	1,327 (0.585)
Odds-ratio							
Distance to capital	0.828	0.886	0.903	0.890	0.920	0.924	0.930
Population in the previous census	1.023	1.112	1.122	1.070	1.025	1.211	1.307
Near highway		6.297	1.080	1.042	1.851	2.297	2.068
Peri-urban municipality			1.269	2.253	3.424	1.844	1.660
Constant	4.272	0.866	4.078	1.482	9.178	1.592	9.107

Notes: The value of the standard error appears in brackets under each coefficient. The number of stars denotes the significance levels at 95%, 99%, and 99.9%.
Source: Authors' elaboration of population census data (ine.es).

because until 1970 there were no urban municipalities in the studied region that were distant from Madrid. Its inclusion in the models due to multicollinearity with the variable distance from the capital is not convenient. This variable is significant in the period 1981–2011 and positively influences the probability that a nonurban municipality is urban–rural. Therefore, it is statistically verified, as the maps already anticipated, that the urban–rural process is predominantly peri-urban, although not exclusively.

In addition to the significance and the sign of the effect of each variable over time, it is interesting to know the magnitude of the impact and how it varies over time. For this, the odds ratio was calculated, which is presented at the bottom of Table 2.

For each additional kilometer of distance to the capital, the probability that the municipality is urban–rural reduced from 17.2% in the 1950s to 7.0% in the 2010s. Therefore, the effect of distance, although still relevant, has decreased, which is consistent with the spatial extension of the urban–ruralization process. This smaller effect occurred as early as in the 1960s, when for each additional kilometer, the probability reduced by 11.4% and by 9.7% in the 1970s.

For every 1,000 additional inhabitants, the probability that the municipality is urban–rural grew 11.2% in the 1960s and 12.2% the following decade. The effect increased and in the last two decades grew to 21.1% and 30.7%, respectively. This has two implications: more urban–ruralization occurs in large municipalities and/or rural municipalities that have lost a lot of inhabitants are getting smaller.

Being in the vicinity of major transport infrastructure approximately doubled the probability that the municipality is largely urban–rural in the last three decades. Being a peri-urban municipality also highly relevant in the distinction between rural and urban–rural municipalities. In the 1990s, areas bordering urban municipalities were more than three times likely to be urban–rural. this effect has recently diminished because the greater spatial extension of urban–ruralization means that a growing part of urban–rural municipalities are not peri-urban.

The importance of proximity to the capital can be seen not only in the maps and the logit models' results but also by observing the evolution of the percentage of nonurban municipalities that are urban–rural in each decade as a function of distance to Madrid. As shown in Figure 3, in 1960 the process of transforming the rural area towards an intermediate stage between the rural and the urban was incomplete, even in municipalities less than 10 kilometers from Madrid.

The process of urban–ruralization has increased since then. In 1970, all nonurban municipalities less than 10 kilometers from Madrid were no longer rural, nor were two-thirds of those located between 10 and 20 kilometers from the capital. Indeed, urban–ruralization expanded 40 kilometers from Madrid. By 1991, a 10% of municipalities between 40 and 50 kilometers from Madrid were urban–rural. By 2001, this figure was 30% and in 2011 60%.

It is interesting to observe how 20 kilometers from the capital there are still some rural municipalities, but the maximum distance from urban–rural municipalities has been growing and is now 80 kilometers. We can therefore conclude that the distance to Madrid plays a major role in the evolution of rural areas to urban–rural ones, but there are other important factors.

5 | DETERMINANTS OF POPULATION CHANGE IN RURAL AND URBAN–RURAL AREAS

After exploring the reasons why some municipalities are rural while others become urban–rural, this section addresses the causes of population change in both rural and urban–rural municipalities.

Some of these potential causes coincide with the explanatory variables of the logit models presented in the previous section, namely, distance to the capital of the urban agglomeration (in this case Madrid), measured in kilometers; population of the municipality in thousands at the beginning of the decade; highway less than five kilometers from the municipality; and peri-urban municipality (it the unit value for the municipalities bordering at least one urban municipality and is zero otherwise).

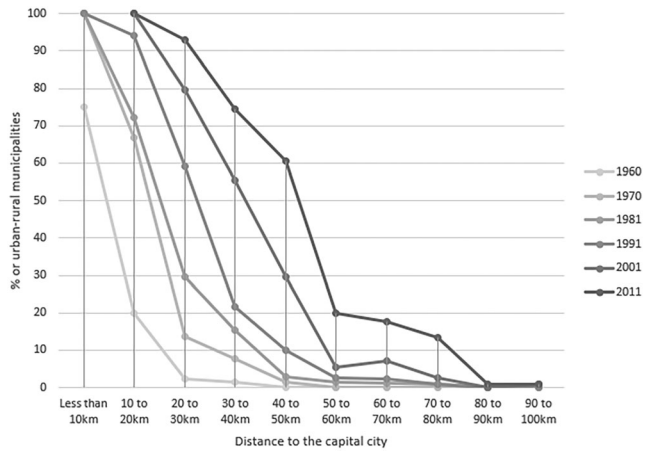

FIGURE 3 Percentage or urban–rural municipalities according to distance to the capital

Additionally, new variables are included that could affect the population dynamics of both rural and urban–rural municipalities. These variables are the following:

1. Altitude in meters above sea level. The rationale for including this variable is twofold: on the one hand, lower elevations tend to have greater accessibility, better climate, more economic development, and historically higher population density. Meanwhile, highlands have worse conditions for economic growth and their initial population density is typically lower (Goerlich Gisbert & Mas Ivars, 2008).
2. Irrigated agriculture. Rainfed agriculture has a much lower productivity per unit area and requires less labor for its maintenance. The municipalities that have a significant portion of irrigated agriculture could have had a better demographic performance in the last few decades.
3. Near a reservoir. During the four initial decades in the studied period, a large number of reservoirs were built in the region. It has been verified that the distance to these reservoirs is insignificant for population change. However, it is hereby presented whether proximity to these reservoirs influenced population growth temporarily or permanently.

Once these seven variables have been defined, the results are presented for the 10-year variation rate of the rural municipal population as a percentage. As explained in the previous section, it is not possible to carry out a panel data model and ordinary least squares regressions are the adequate models, as confirmed by the appropriate statistical tests. By including seven variables, several of them spatial, the possibility of high multicollinearity arose, but in practice, did not occur. The results of the variance inflation factor (VIF) ratio are offered in the bottom part of Table 3. They are very close to the unit in every decade, so none of the explanatory variables should be removed from the models.

The distance to the capital is always significant and negative, although the effect differed depending on the decade considered. Thus, for each additional kilometer in the 1940s, an average of 0.025% of the population were lost, while in the first decade of the twenty-first century this figure reached 0.232%. The effect seems to have been greater in recent decades, except during the last period when it diminished.

Population size at the beginning of each decade is also a significant variable except for during the 1940s. Larger rural municipalities found their population increased more or decreased to a lesser extent than more sparsely populated municipalities. Thus, for every 1,000 additional inhabitants in the last decade, the population variation rate increased by 1.68%. This figure reached 2.89% in the 1970s and 2.50% in the 2000s.

The accessibility of main transportation infrastructure is also a significant determinant of population change in almost every decade and always contributes positively. For example, in the last decade, the municipalities close to highways changed their population 3.68% more than those without nearby major transport routes.

Altitude is also a variable that affects population change, and it does so significantly for all decades except the 1990s. For example, for every 100 meters above sea level, the population decreased an additional 0.4% in the last decade. The lowlands therefore suffered less depopulation than the highlands, a finding replicated for at least the last 80 years in the area studied.

Bordering an urban municipality increases rural local units' populations greatly. This variable is introduced in the models from 1970 onwards because beforehand there was a high correlation with the distance to Madrid since the capital was the only urban municipality. Being in the vicinity of a city increased a rural municipality's population change by an extra 5.1% in the last decade.

Despite the proposed hypothesis, the existence of irrigated agriculture was only significant in one of the eight decades: during the 1960s, it seemed to contribute slightly to avoiding rural depopulation. Otherwise, this intervention—usually funded by regional public funds or European Union programs—showed little effect in the area studied.

Regarding proximity to reservoirs, the effect on population dynamics was negative and significant during the decades they were built. This could be due to the reduction of the land destined for cultivation in the municipalities

TABLE 3 Ordinary least squares regressions for rural units by decade

Variable	1940–1950	1950–1960	1960–1970	1970–1981	1981–1991	1991–2001	2001–2011	2011–2021
Distance to capital	−0.025 ** (0.01)	−0.076 *** (0.01)	−0.126 *** (0.01)	−0.120 *** (0.01)	−0.137 *** (0.01)	−0.203 *** (0.02)	−0.232 *** (0.02)	−0.065 *** (0.01)
Population in the previous census	0.229 (0.17)	0.842 *** (0.14)	1.916 *** (0.19)	2.894 *** (0.25)	0.805 *** (0.23)	0.562 * (0.28)	2.499 *** (0.50)	1.676 *** (0.33)
Near highway	1.375 (0.78)	2.617 *** (0.71)	5.644 *** (1.00)	5.090 *** (1.03)	1.782 (1.08)	1.730 (1.44)	3.173 * (1.28)	3.677 *** (0.94)
Altitude	−0.012 *** (.002)	−0.005 ** (.002)	−0.013 *** (.002)	−0.021 *** (.002)	−0.009 *** (.002)	−0.003 (.003)	−0.011 *** (.003)	−0.004 * (.002)
Peri-urban municipality				12.522 * (5.83)	4.917 * (2.45)	7.849 * (3.59)	10.198 ** (3.72)	5.100 * (2.03)
Irrigated agriculture	−0.462 (0.97)	0.401 (0.89)	2.553 * 1.252)	−0.018 (1.29)	−0.994 (1.34)	−1.265 (1.78)	1.086 (1.58)	0.598 (1.15)
Near reservoir	−0.713 (1.03)	−2.751 ** (0.94)	−4.833 ** 1.325)	−4.404 ** (1.38)	3.791 ** (1.43)	1.922 (1.92)	1.550 (1.68)	−1.007 (1.22)
Constant	16.696 *** (1.67)	4.443 ** (1.68)	−8.410 *** 2.374)	0.300 (2.49)	9.703 *** (2.62)	15.194 *** (3.54)	27.160 *** (3.43)	−8.464 ** (2.48)
No. of observations	1,355	1,345	1,321	1,299	1,271	1,213	1,136	1,136
Adj. R^2	0.0681	0.1438	0.2608	0.3051	0.153	0.1219	0.2421	0.111
VIF	1.14	1.14	1.12	1.11	1.11	1.1	1.11	1.13

Notes: The value of the standard error appears in brackets under each coefficient. The number of stars denotes the significance levels at 95%, 99% and 99.9%.
Source: Authors' elaboration of population census data (ine.es).

near the reservoirs since this land would be under water. In contrast, in the 1980s the effect continued to be significant but turned positive. It would be necessary to study in detail in which cases this is due to a partial return of the previously emigrated population and in which the cause is more of the population remaining in the area. The construction of reservoirs was an important policy decades ago in most European countries, and the long-term effect on population dynamics in the surrounding areas is still not well-studied (Table 4).

Again, in this case the VIF values are low, although not as low as in the models exploring the causes of change in the rural population. However, there is no multicollinearity between the variables in any of the cases.

Nonsignificant models are found (see R^2 adjusted), and only the population at the beginning of the decade is significant between 1981 and 2011; the *p*-value in the 1990s is 0.054, very close to the limit of significance. A greater population of these urban–rural municipalities would contribute to their growth being lower. The other six variables examined do not have an effect in any of the periods. In the case of these urban–rural municipalities, the population change would mainly be due to the availability of new housing, a decision emanating from the local and regional public authorities as well as from construction companies, who, once the new areas to be developed have been established, decide whether to carry out the projects or not.

The fact that it is not possible to explain the different population growth of these municipalities is therefore not unexpected, but rather contributes to prove that the results presented in Table 3 for rural municipalities are indeed correct and significant, since the variation of the population in rural areas comes from the individual decisions of each of the inhabitants who decided to emigrate or not as well as the number of descendants they had. However, the growth of urban–rural areas has a different nature.

TABLE 4 Ordinary least squares regressions for urban–rural units by decade

	1960–1970	1970–1981	1981–1991	1991–2001	2001–2011	2011–2021
Distance to capital	−0.073 (0.067)	−0.018 (0.010)	−0.030 (0.027)	−0.010 (0.011)	0.000 (0.005)	−0.001 (0.001)
Population in the previous census	0.061 (0.194)	0.003 (0.034)	−0.110 * (0.052)	−0.087 (0.045)	−0.064 *** (0.017)	−0.002 (0.003)
Near highway	−0.388 (5.899)	−0.539 (0.371)	0.112 (0.873)	0.166 (0.528)	0.049 (0.187)	−0.028 (0.043)
Altitude	−0.001 (0.007)	0.000 (0.001)	0.000 (0.002)	0.000 (0.001)	0.000 (0.000)	0.000 (0.000)
Peri-urban municipality		−0.005 (0.288)	1.226 (0.697)	−0.079 (0.493)	0.351 (0.184)	0.004 (0.042)
Irrigated agriculture	0.136 (2.133)	0.244 (0.332)	1.694 (0.925)	−0.178 (0.672)	−0.112 (0.245)	0.046 (0.057)
Near reservoir	−1.006 (4.446)	−0.334 (0.351)	0.692 (0.956)	−0.653 (0.620)	−0.381 (0.255)	−0.002 (0.058)
Constant	4.527 (7.960)	2.029 * (0.795)	1.653 (1.836)	2.178 (1.157)	1.438 ** (0.425)	0.128 (0.098)
No. of observations	31	42	69	123	193	191
Adj. R2	−0.1612	0.0173	0.0667	−0.0121	0.0669	−0.0226
VIF	1.89	1.48	1.29	1.18	1.17	1.22

Notes: The value of the standard error appears in brackets under each coefficient. The number of stars denotes the significance levels at 95%, 99% and 99.9%.

Source: Authors' elaboration of population census data (ine.es).

6 | CONCLUSIONS AND RECOMMENDATIONS

Classifying the population into urban versus rural is insufficiently precise. It is necessary to include a third category, the urban–rural classification, because, although it is predominantly peri-urban, it also includes previously rural municipalities that are not in the vicinity of urban areas. The current methodology recommended by six international organizations, including the European Commission, the Organization for Economic Cooperation and Development, the United Nations, and the World Bank, uses population grids that are not available for past periods. Therefore, their methodology was modified to be used with data from local areas. This article then used this method to classify municipalities in a Southern European region as a case study to show how the urban–rural phenomenon started and expanded.

The region near Madrid, the fourth largest European urban agglomeration, was studied to draw conclusions and recommendations for applying policies not only in the area but also to similar locations in similar countries. If the urban–rural category is not included, the phenomenon of rural depopulation cannot be observed, but when it is included, a marked decrease in the number of inhabitants in rural areas is evident. Likewise, the inclusion of this third category allows us to observe the spatial limits of the relevant area of influence of both large and small cities over the last few decades, since the methodology used does not require the use of population density grid maps.

Section 4 analyzes the determinants that transform some rural municipalities into urban–rural ones. The reasons are proximity to the capital, larger population size, proximity of main transport networks, and bordering urban municipalities. This number of areas that are neither urban nor rural has increased since this process began in the middle of the twentieth century: it occupies more space, and it also affects the outskirts of small cities. Urban–rural areas are predominantly but not exclusively peri-urban and are sometimes found in municipalities surrounded by others that remain rural.

Rural depopulation is an important issue since it happens in almost all developed countries. It also occurs in the vicinity of a city as large as Madrid once urban–rural municipalities are excluded from the classification of rural areas. This depopulation process has occurred for at least the last eight decades, and its causes are studied in Section 4.

The municipalities most affected by depopulation in recent decades are those that meet the following characteristics: 1) they are located farther from a large city and do not border urban areas, 2) they have smaller populations, 3) they are not located near main transport infrastructure, and 4) they are located at a higher altitude above sea level. Based on this classification, it is possible to identify rural areas that have experienced poorer population dynamics in recent decades and will almost certainly continue to do so in the future. Regarding the third point mentioned, the conclusion is drawn that transport infrastructure has a positive impact on population growth in rural areas or at least curbs depopulation. However, it should be emphasized that only the main road routes of the national network were considered in this study. Therefore, it is not feasible to build more existing infrastructure than is necessary, both because of its high cost and because its duplication would probably reduce this positive effect on population growth.

For the purposes of public policies, it is relevant that the presence of irrigated agricultural land did not have a positive impact on population dynamics in the analyzed region's rural areas, except in the 1960s, where it had a slightly positive influence. Currently, public resources are allocated for the transformation of rainfed agricultural areas into irrigated ones. Of course, these policies have a positive effect at the economic level, for example, by increasing the price of land, but in terms of increasing the resident population, the effect is debatable.

Finally, another possible policy that would affect the rural population is the construction of reservoirs, although in recent decades this has hardly happened in Western countries due to its high ecological impact. Building reservoirs was found to negatively impact the population dynamics of the surrounding rural areas during and immediately after construction, possibly due to the loss of arable land and therefore a decrease in available jobs. However, in the area studied, their effect temporarily turned positive, and the population of these decreased to a lesser extent during the 1980s.

Interestingly, population dynamics of urban–rural areas cannot be explained by the variables. This is probably since these municipalities grew because of political and economic decisions related to the real estate sector.

Future research includes extending the scope of this study to nearby regions of other large European agglomerations as well as to the surrounding areas of small cities. It would also be interesting to replicate the study for regions with a high level of urban–rural areas, such as the Mediterranean coast. In that case, it would be interesting to complement the distance to large population centers with the distance to the sea.

ORCID

Juan Luis Santos https://orcid.org/0000-0001-5373-1761

REFERENCES

Arellano, M. (1993). On the testing of correlated effects with panel data. *Journal of Econometrics*, *59*(1–2), 87–97. www.sciencedirect.com/science/article/abs/pii/030440769390040C

Ayuda, M. I., Collantes, F., & Pinilla, V. (2010). From locational fundamentals to increasing returns: The spatial concentration of population in Spain, 1787–2000. *Journal of Geographical Systems*, *12*(1), 25–50. https://link.springer.com/article/10.1007/s10109-009-0092-x

Bauer, G., & Roux, J. M. (1976). *La rurbanisation ou la ville éparpillée*. Éditions du Seuil.

Brenner, N., & Schmid, C. (2014). The 'urban age' in question. *International Journal of Urban and Regional Research*, *38*(3), 731–755. https://onlinelibrary.wiley.com/doi/abs/10.1111/1468-2427.12115

Camagni, R., Capello, R., & Caragliu, A. (2016). Static vs. dynamic agglomeration economies. Spatial context and structural evolution behind urban growth. *Papers in Regional Science*, *95*(1), 133–159. https://doi.org/10.1111/pirs.12182

Capello, R., Caragliu, A., & Gerritze, M. (2022). Continuous vs. discrete urban ranks: Explaining the evolution in the Italian urban hierarchy over five decades. *Economic Geography*, *98*, 438–463. https://doi.org/10.1080/00130095.2022.2074830

Caruso, G. (2001). Periurbanisation, the situation in Europe: A bibliographical note and survey of studies in the Netherlands, Belgium, Great Britain, Germany, Italy and the Nordic countries. DATAR. https://orbilu.uni.lu/bitstream/10993/10153/1/Caruso_PeriUrbanEuropeDATAR.pdf

Champion, T. (2001). Urbanization, suburbanization, counterurbanization and reurbanization. In *Handbook of urban studies*, Part III:The City as People (Chap. 9, pp. 143–161). SAGE Publications. https://sk.sagepub.com/reference/hdbk_urban/n9.xml

Davidson, R., & MacKinnon, J. G. (1984). Convenient specification tests for logit and probit models. *Journal of Econometrics*, *25*(3), 241–262. www.sciencedirect.com/science/article/abs/pii/0304407684900010

Dijkstra, L., Garcilazo, E., & McCann, P. (2013). The economic performance of European cities and city regions: Myths and realities. *European Planning Studies*, *21*(3), 334–354. https://doi.org/10.1080/09654313.2012.716245

European Commission – Eurostat and DG for Regional and Urban Policy – ILO, FAO, OECD, UN-Habitat. and World Bank. (2020). A recommendation on the method to delineate cities, urban and rural areas for international statistical comparisons. Items for discussion and decision: demographic statistics. https://ec.europa.eu/eurostat/cros/system/files/bg-item3j-recommendation-e.pdf

Firmino Costa da Silva, D., Elhorst, J. P., & Silveira Neto, R. d. M. (2017). Urban and rural population growth in a spatial panel of municipalities. *Regional Studies*, *51*(6), 894–908. https://doi.org/10.1080/00343404.2016.1144922

Follmann, A., Kennedy, L., Pfeffer, K., & Wu, F. (2022). Peri-urban transformation in the global south: A comparative socio-spatial analytics approach. *Regional Studies*, *1-15*, 1–15. https://doi.org/10.1080/00343404.2022.2095365

Goerlich Gisbert, F. J., & Mas Ivars, M. (2008). Algunas pautas de localización de la población española a lo largo del siglo XX. *Investigaciones Regionales-Journal of Regional Research*, (12), 5–34. https://investigacionesregionales.org/es/article/algunas-pautas-de-localizacion-de-la-poblacion-espanola-a-lo-largo-del-siglo-xx/

Jacobs-Crisioni, C., & Koomen, E. (2017). Population growth, accessibility spillovers and persistent borders: Historical growth in west-European municipalities. *Journal of Transport Geography*, *62*, 80–91. https://doi.org/10.1016/j.jtrangeo.2017.05.008

Khanani, R. S., Adugbila, E. J., Martinez, J. A., & Pfeffer, K. (2021). The impact of road infrastructure development projects on local communities in peri-urban areas: The case of Kisumu, Kenya and Accra, Ghana. *International Journal of Community Well-Being*, *4*(1), 33–53. https://link.springer.com/article/10.1007/s42413-020-00077-4

Le Gallo, J., & Chasco, C. (2008). Spatial analysis of urban growth in Spain, 1900–2001. *Empirical Economics*, *34*(1), 59–80. https://link.springer.com/article/10.1007/s00181-007-0150-5

Lefebvre, H. (1970). *La révolution urbaine* (Vol. 216). Gallimard.

Martori, J. C. (2010). Las consecuencias del boom inmobiliario. Cambios en la densidad de las metrópolis españolas, 2001-2007. *Scripta Nova*, *14*, 1–20. https://revistes.ub.edu/index.php/ScriptaNova/article/view/1638

Muñiz, I. O. (2019). Definir la urbanización periférica: Conceptos y terminología/defining the urban periphery: Concepts and terminology. *Ería*, *2*(2), 183–206. https://reunido.uniovi.es/index.php/RCG/article/view/13691/12540

Nilsson, K., Pauleit, S., Bell, S., Aalbers, C., & Nielsen, T. A. S. (Eds.). (2013). *Peri-urban futures: Scenarios and models for land use change in Europe*. Springer Science & Business Media. https://link.springer.com/book/10.1007/978-3-642-30529-0

Organisation for Economic Co-operation and Development. Working Party on Territorial Indicators. (2012). Redefining" urban": A new way to measure metropolitan areas. OECDiLibrary. https://doi.org/10.1787/9789264174108-en

Portnov, B. A., Axhausen, K. W., Tschopp, M., & Schwartz, M. (2011). Diminishing effects of location? Some evidence from Swiss municipalities, 1950–2000. *Journal of Transport Geography*, *19*(6), 1368–1378. https://doi.org/10.1016/j.jtrangeo.2011.07.017

Pozo Rivera, E., & Rodríguez Moya, J. (2006). Transformaciones sociodemográficas recientes en las comarcas Castellano Manchegas limítrofes con la Comunidad de Madrid. *Anales de geografía*, *26*, 249–281. https://revistas.ucm.es/index.php/AGUC/article/view/AGUC0606110249A

Ravetz, J., Fertner, C., & Nielsen, T. S. (2013). The dynamics of peri-urbanization. In *Peri-urban futures: Scenarios and models for land use change in Europe* (pp. 13–44). Springer. https://link.springer.com/chapter/10.1007/978-3-642-30529-0_2

Redfearn, C. L. (2009). Persistence in urban form: The long-run durability of employment centers in metropolitan areas. *Regional Science and Urban Economics*, *39*(2), 224–232. https://doi.org/10.1016/j.regsciurbeco.2008.09.002

Taylor, P. J., & Lang, R. E. (2004). The shock of the new: 100 concepts describing recent urban change. *Environment and Planning a*, *36*(6), 951–958. https://journals.sagepub.com/doi/10.1068/a375

Viñuela, A., & Fernández-Vázquez, E. (2012). From the periphery to the core: Direct and indirect effects of the migration of labour. *Review of Regional Research*, *32*(1), 1–18. https://link.springer.com/article/10.1007/s10037-011-0059-5

Vorms, C. (2017). Naming Madrid's Working-Class Periphery, 1860-1970: The construction of the urban illegitimacy. In R. Harris & C. Vorms (Eds.). *What's in a name? Talking about urban peripheries* (pp. 209–320). University of Toronto Press. www.degruyter.com/document/doi/10.3138/9781442620643-012/html

How to cite this article: Santos, J. L., & Fernández Fernández, M. T. (2022). The spread of urban–rural areas and rural depopulation in central Spain. *Regional Science Policy & Practice*, 1–15. https://doi.org/10.1111/rsp3.12605