LUND UNIVERSITY
School of Economics and Management

Master's Programme in Economic Development and Economic Growth

# The effect of mine closures on depopulation in the Principality of Asturias, Spain

by

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**Abstract** The paper examines the impact of the mining sector's closure on population decline patterns in the Principality of Asturias, Spain. It utilizes two distinct databases of own construction that provide disaggregated data on the region's 78 councils. The first database encompasses demographic information spanning from 1900 to the present day, while the second database contains socioeconomic data from 2001 onwards. Initially, a descriptive analysis is conducted to provide historical context to the evolution of demographic trends. Subsequently, an econometric analysis investigates the correlation between demographic and socioeconomic variables, as well as the relationship between each council and mining. Finally, synthetic control methods are applied to estimate the effects of mine closures on the selected councils. The findings indicate a negative impact of mine closures on the councils heavily reliant on the mining sector. While population decline trends were evident prior to mine closures, the combination of this shock and the absence of viable alternatives aggravated the situation significantly.

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## 1. Introduction

As a result of the changes that have taken place over the last few decades, new demographic trends are one of the major challenges currently faced by most developed countries and have been placed at the top of the agenda of most governments. In the case of Europe, the European Union has already developed a plan to address the challenges caused by, among other factors, the way in which population structures have been redefined. Roughly, the main points that are being addressed relate to the aging of the population, the decline in birth rates and the delay in childbearing, and the role played by migratory processes. Within the European Union, Spain is one of the countries where the impact of demographic changes has become most visible, especially in recent decades. In particular, depopulation in some areas of the country is especially alarming. Over the 21$^{st}$ century, the Autonomous Communities of Extremadura, Galicia, Castilla y León and Asturias have experienced population loss. However, considering the last decade, the Autonomous Communities of Aragon, Cantabria, Castilla-La Mancha, the Valencian Community and La Rioja also join this list (General Secretariat for the Demographic Challenge, 2022). Another implication of this demographic shift in Spain has resulted in a negative natural increase of the population since 2015, which is also expected to continue over the next few decades. Once again, the Communities of Galicia, Asturias and Castilla y León present the most discouraging figures. However, the general picture is also not too promising since eight out of ten municipalities have had negative vegetative growth since the last decade (INE, 2022). In this context, it is impossible to isolate a unique factor, as there are many reasons why depopulation affects numerous territories, and they are often interrelated. As mentioned above, the Principality of Asturias is one of the leading Autonomous Communities in terms of depopulation. According to the latest Population and Housing Census figures of the Spanish Institute of Statistics[1] (2021), Asturias accounts for seven of the eight Spanish municipalities that have lost the most population in the last ten years, with an Asturian council leading this ranking. Furthermore, six of the twenty municipalities with the lowest economic activity rates are also Asturian. In relation to this is developed the main argument of this research, which aims to analyze the role of the mining sector in the depopulation processes of the Principality of Asturias.

[1] The acronym INE will also be used throughout the analysis.

The history of Asturias is the history of many other regions in the world that stood out for their mining sector at the beginning of the 20th century. From Canada to China, through Belgium or Germany, the new emerging energy resources of the middle of the 20th century displaced coal mining as the main economic activity of many regions in the world that had previously sustained most of their production in the sector. However, contrary to other regions such as the Ruhr in Germany or Wallonia in Belgium, there has been no industrial restructuration in Asturias. In this context, the lack of productive alternatives capable of sustaining the existing productive structure has led the most affected areas of the region to dismantle all activity completely. As a result, the population loss processes, which are present in many regions of Europe, and especially in Spain, have been accelerated. The high levels of unemployment, significantly higher in the areas where mining activity was concentrated, would have been one of the determinants contributing, among other aspects, to the decline in fertility and immigration rates. In the case of the latter, people who had migrated to Asturias to be employed in the mines would have played a significant role in the region's growth. In the same way, the lack of labor alternatives, especially among young people, would also have triggered emigration to other areas of Asturias or Spain, and internationally.

In this context, the present analysis tries to establish and quantify the relationship between the closure of the last mining shafts in those Asturian municipalities where they were still operating after 2001, the first year for which it is possible to find disaggregated socioeconomic data at the council level, and the trends that point towards a generalized population loss. For this purpose, two databases of own construction will be used, which collect information on the 78 Asturian councils, and two different approaches will be used for their analysis. As a first step, four councils where the mining sector would have been the main economic activity are identified and defined as "Mining", while another four where the main activity was not mining are defined as "Non-mining" and used as a control group. Subsequently, using data from the beginning of the 20th century to the present, the situation and context of Asturias is analyzed from a historical perspective, starting with the weight of the mining sector in the Principality and the importance of its closure in terms of population levels and structure. Next, and using more recent data, covering from the beginning of the 21st century to the present, the impact of the closure of the mining industry on different socio-demographic characteristics of the Asturian territory and its relationship with the relationship of the municipalities with the mining activity is analyzed. While the first part of the analysis is carried out from a mainly descriptive point of view, in this second part econometric methods are used to determine the impact of the different variables selected. Finally, the synthetic control method is applied in order to try to discern the real effect of the closure of the main mining shafts in the selected councils. The following paragraphs will contextualize the region's situation and describe the trends in population levels over the last century. Afterward, the studied variables will be defined, and their correlation level will be analyzed to proceed to explain and implement the synthetic control method. Finally, the last section discusses the results obtained, which indicate a significant impact of the closure of the last mining shafts in the affected councils, and the possible causes of this impact.

## 2. The depopulation phenomenon

Depopulation is a demographic and territorial phenomenon, which consists of a decrease in the number of inhabitants of a territory or nucleus in relation to a given period. The fall in absolute terms of the number of inhabitants can result from either a negative vegetative growth[2], a negative migratory balance[3], or both simultaneously. Therefore, the causes are complex and require an in-depth analysis in order to make a proper diagnosis. Economic factors play a crucial role in depopulation processes: the areas affected by them are usually economically depressed, backward, or less dynamic compared to other regions of the same country (Kibirige, 1997; Coale & Hoover, 2015; Simon, 2019). In general, depopulation processes have been triggered in Europe as a consequence of the high rates of migration from rural areas to the expanding urban centers. This phenomenon was known in the first decades of the second half of the 20th century as the rural exodus due to its magnitude and impact on the emigrants' places of origin. Some of the reasons that led so many people in most European countries to migrate to cities were the access to higher wages, greater job opportunities, and their larger number of facilities and services. In short, people migrated to urban areas because of their ability to provide higher levels of material well-being. As for the regions of origin of these emigrants, depopulation may have had significant effects by laying the foundation stone of a dangerous dynamic, since, as young and adult populations are the ones who predominantly tend to emigrate, aging

[2] The difference between birth and death rates.
[3] The difference between total number of immigrants and emigrants.

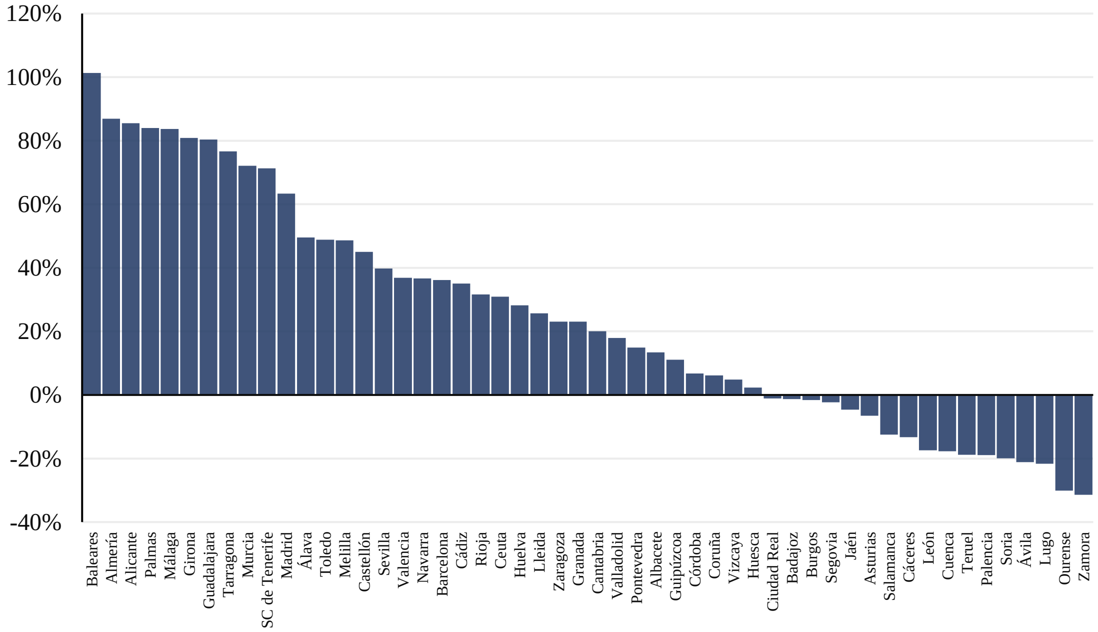
is an unequivocal consequence in their homelands. In addition, this leads to low birth rates due to the scarcity of population in the reproductive ranges, so the vegetative growth is negative. This may lead to a situation where, even when outflows weaken, depopulation will continue as deaths may even exceed births. In addition, population loss tends to generate vicious feedback loops that compromise the future of the areas that suffer the most from it. Thus, the loss of human capital of the most entrepreneurial people takes place, which reduces their economic dynamism. Investment or entrepreneurial decisions themselves are depressed as a result of low expectations (Acs et al., 2012; Hopenhayn et al., 2022). In summary, demographic decline is often accompanied by economic decline.

Depopulation phenomena can occur in all areas, including large cities and densely populated areas. However, when they affect low-density areas, unbalanced in terms of age structure, gender, and qualifications, and lack an urban system that provides the backbone of their territory, the future outlook is especially negative. For these declining rural communities throughout Europe, demographic desertification is a symptom of serious structural problems that could lead to their disappearance in the short term, that is, to the truncation of personal projects and the erasure of communities with a long history and even great future potential. Thus, its political management is challenging to design and implement because, in addition to the need to outline strategies that integrate different levels of government in a strategic sense, it requires a very virtuous execution.

### 2.1. An Overview of Depopulation in Spain

Following the same pattern repeated throughout Europe, depopulation in Spain is more prevalent in predominantly rural areas. In general terms, the Spanish population has increased by around 38% between 1975 and 2021, from 34.2 to 47.3 million inhabitants (INE, 2021). Such an increase, however, can only be observed in certain areas. Over this period, during which the country has undergone a substantial economic transformation, many regions have been affected by large-scale migratory movements from the more rural areas to the larger cities. Overall, according to the Spanish National Institute of Statistics (2022), nine autonomous communities lost population during the decade from 2010 to 2019: Aragón, Asturias, Cantabria, Castilla y León, Castilla-La Mancha, Comunidad Valenciana, Extremadura, Galicia and La Rioja. Figure I shows this trend for the period from 1975 to 2021. However, the phenomenon of depopulation is particularly noticeable at the municipal level, with 6,232 of the 8,131 municipalities losing population during the last decade, amounting to a total of 3 out of every 4 of them. Even so, it is an eminently rural phenomenon, affecting small municipalities most severely. In Spain, 12% of the population lives in municipalities of less than 5,000 inhabitants, and 8 out of 10 have lost population during the last decade. Moreover, 86% of municipalities with less than 1,000 inhabitants have seen their population decline. The severity of the problem has become one of the most frequently addressed issues, with the so-called "Empty Spain" being placed on the political agenda of numerous administrations as one of the challenges to be overcome during the subsequent legislatures.

*Figure I: Population growth rate by provinces in Spain from 1975 to 2021*



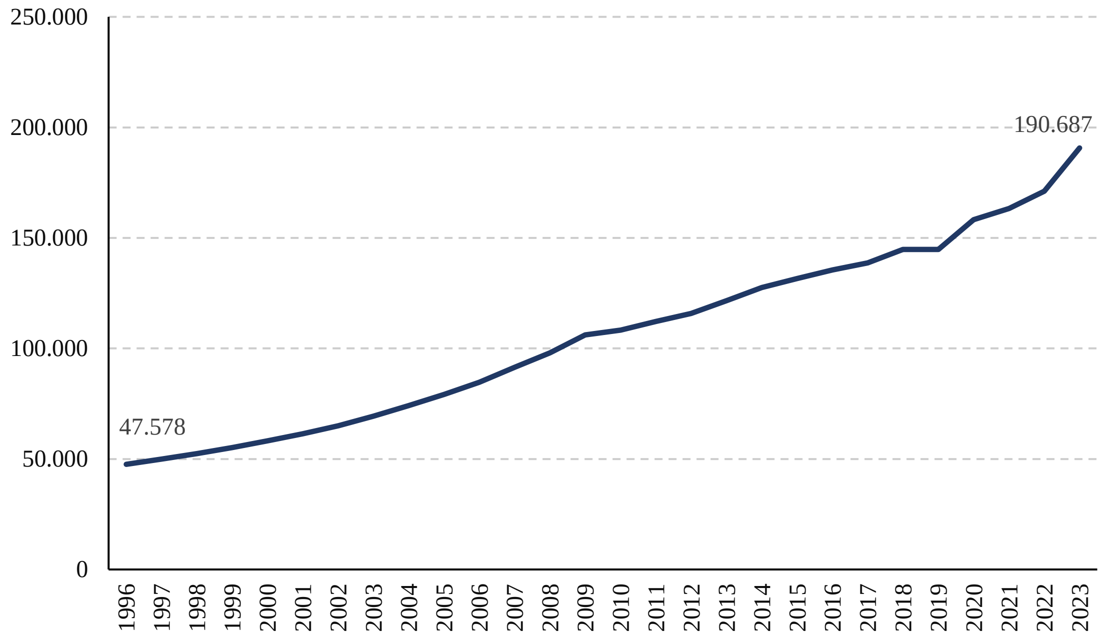

*Source: Own elaboration based on INE data (2021)*

As can be noted from the above graph, the severity of the situation and the magnitude of depopulation are not the same in all the autonomous communities. Asturias and Castilla y León are among the most affected ones by population loss in their municipalities. According to INE estimates (2021), more than 85% of them had less population in 2020 than they had in 1996. After these two, Extremadura and Aragón are the territories in which a higher percentage of municipalities have seen their population decrease. As mentioned previously, the main reason some areas face a higher degree of depopulation is to be found in emigration from rural areas to the expanding urban ones. From the beginning of the 2000s to 2020, the population of municipalities with 1000 or fewer inhabitants has fallen by 8.9% (142,000 inhabitants less), from representing 4% of the total population in 2000 to 3.1% in 2018. Regarding the destination of the people who emigrate, most of them stay in the national territory, Madrid, Barcelona and Valencia are the cities whose population has increased to a greater extent due to immigrants arriving from rural areas of other parts of Spain (INE, 2021). However, some provincial capitals and medium-sized cities such as Zaragoza or Palma de Mallorca have also experienced considerable growth due to this phenomenon.

When it comes to the consequences of these trends, one of the most notable has to do with the aging of the population in the most depopulated areas, and that is the proportion of people over 65 years of age to the total population has increased from 9% in 1971 to 19% in 2019 (INE, 2020). Currently, one in every five people in Spain is over 65. However, projections estimate that in 2050 it will be one in every four. The situation is even worse in municipalities with less than 1,000 inhabitants, where three out of every ten are over 65 and 15% of the population is over 80. This is one of the consequences of the demographic change that Spain has undergone in recent decades, which has led to a negative natural population increase since 2015. In this regard, the most recent projections estimate that the difference between the number of births and deaths will continue to follow this trend in the coming decades. At the municipal level, the natural increase rate is already negative in eight out of every ten and at the autonomous community level, Asturias, Castilla y León, and Galicia have had negative rates since the 1980s.

The emigration of younger people increases the average age in these municipalities, with the consequent effects on different matters, being the fiscal aspect among the most outstanding ones. Although the average retirement age has risen from 63.6 in 2005 to 64.4 in 2020, pension expenditure has not ceased to grow since the end of the 1990s. Figure II shows the evolution of the budget allocated to paying pensions as part of the National Budget. It can be seen how the trend underwent a significant upturn from 2018 onwards, coinciding with the consummation of depopulation trends in many parts of the country.

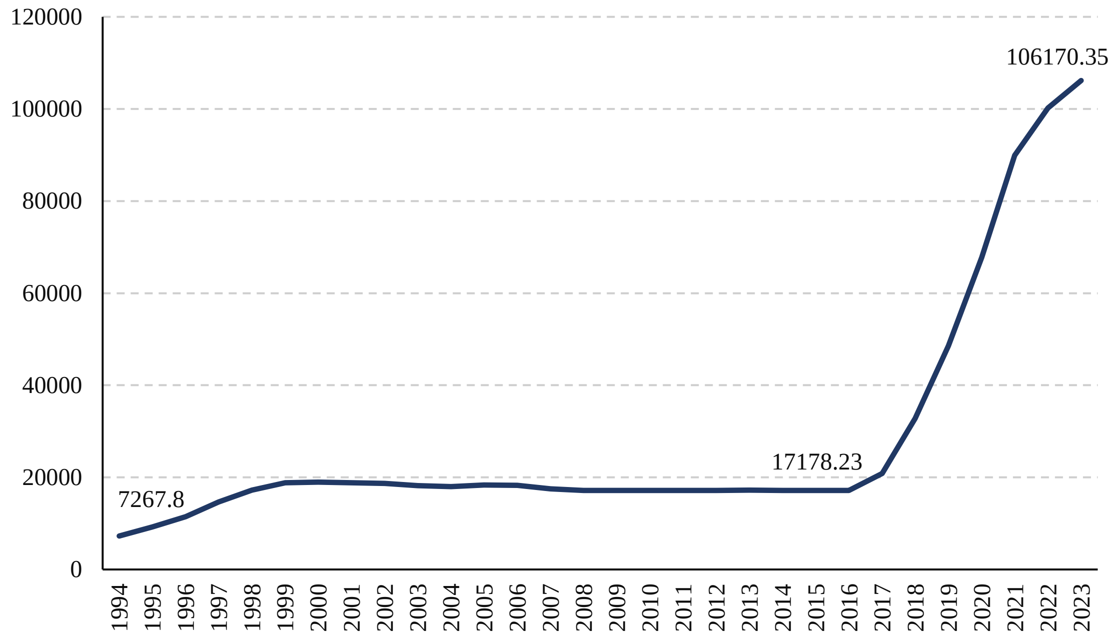
*Figure II: Evolution of the budgeted expenditure on pensions, 1996-2023*




*Source: Own elaboration based on data from the Spanish Ministry of Finance, 2023*

In addition, besides the portion of the National Budget, there is also the Social Security Reserve Fund, which has been used in recent years to pay the "extra" pension bonuses in July and December. Currently, the funds equal €2,150 million, compared to the €66,815 million available in 2011 (Spanish Ministry of Social Security, 2023). Moreover, as Figure III shows, the Social Security Debt has also escalated dramatically since 2018. It had remained steadily below 20 billion up to that date, a sharp contrast compared to the more than 106 billion reported by the latest data provided by the Central Bank of Spain (2022), which coincides with the highest amount in the country’s history.

*Figure III: Evolution of the Social Security debt, 1994-2023*

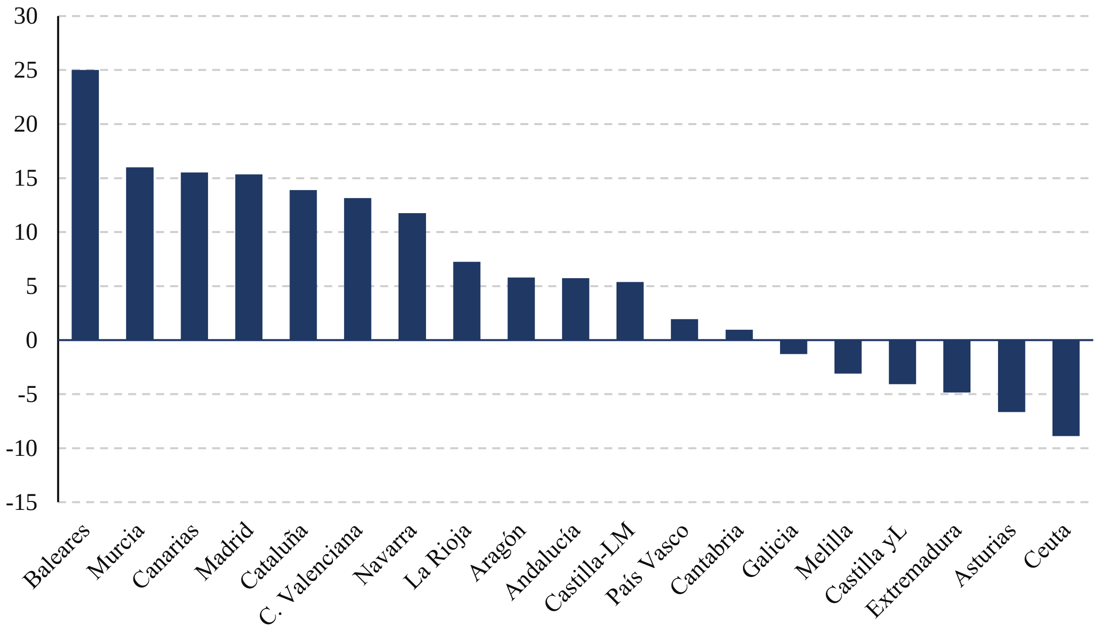



*Source: Own elaboration based on data provided by the Central Bank of Spain, 2023*

Lastly, in relation to population aging and how the different trends are interrelated, and although the migration ones mentioned above are of key importance, another important factor to be mentioned is the evolution of the average age at which women have their first child. In Spain, it was 25 years in 1975, while the latest INE estimates (2023) indicate that it is currently 31 years. Regarding the impact of these trends on fertility rates, the literature points to the effect of having the first child at an older age on the total number of children conceived (ESHRE, 2005; Balasch & Gratacós, 2011; Herr, 2016). In this regard, and although, as already mentioned, both in the case of Europe and Spain, certain areas are significantly more aged and losing more population than the rest, the combination of both trends, the rise in life expectancy and the fall in fertility, are added to the main determinants of the general aging of the population.

As for the future, the latest projections of the Spanish National Institute of Statistics (2022) indicate that the total population will continue increasing from more than 47 million to more than 52 million in 2072. Regarding the natural population growth rate, this would remain negative, and the difference between the number of deaths and births would widen even more from 2030 onwards. This trend was effectively consolidated in 2015, when deaths exceeded births for the first time in the last century. When looking at the particular cases of each autonomous community, Figure IV below shows how, after the autonomous city of Ceuta, the Principality of Asturias would be the one that would experience a greater loss from 2022 to 2037. If these projections were confirmed, the region's future would be dangerously close to the severest levels of depopulation, especially in certain areas.

*Figure IV: Projections of the percentage change in population by Autonomous Community, 2022-2037*



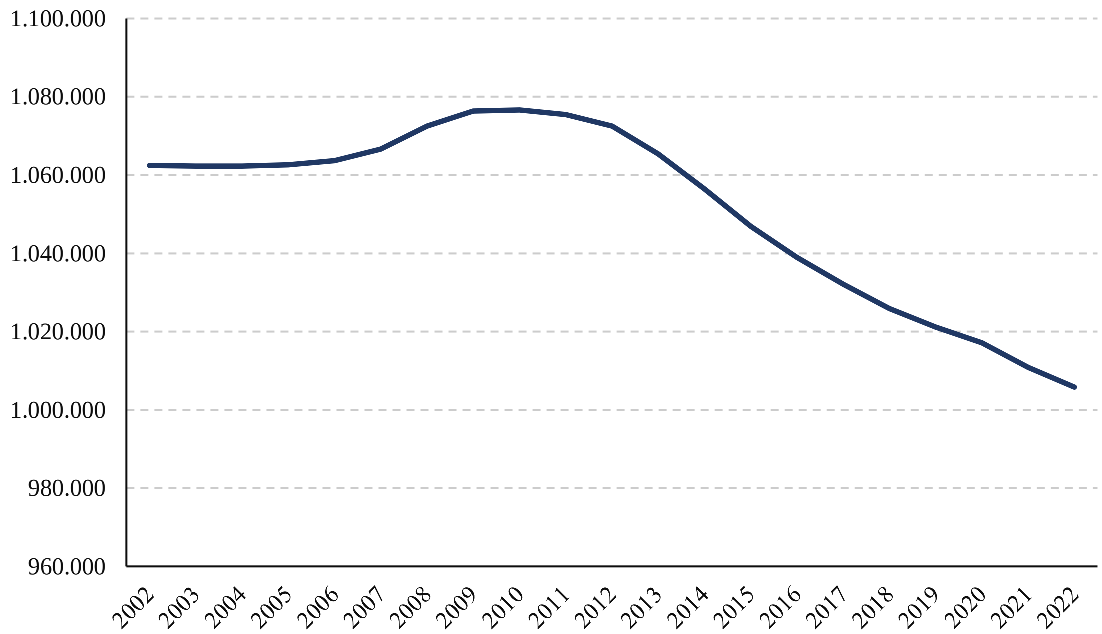

*Source: Own elaboration based on data provided by the Central Bank of Spain, 2023*

After this overview of the depopulation situation in Spain, the following section will explore these trends in the specific case of the Asturian region, from the potential reasons to its severity and the geographical areas in which they are most notably present.

## 2.2. Depopulation in Asturias

Looking at the data from the Spanish National Institute of Statistics (2023), ten of the fifty municipalities that suffered the greatest population loss between 2019 and 2020 were in Asturias. Figure V illustrates the population decline in the region during the last decades. Additionally, it can be seen how population loss has accelerated notably since 2012. Although the period covered by the graph is only from 2002 to 2022, Asturias has lost nearly 60,000 inhabitants in these twenty years, representing about 6% of the total population. Moreover, official estimations are not providing more optimistic forecasts, and it is expected that the population of Asturias will decrease by almost 70,000 people by 2037, nearly 7% of the current population.

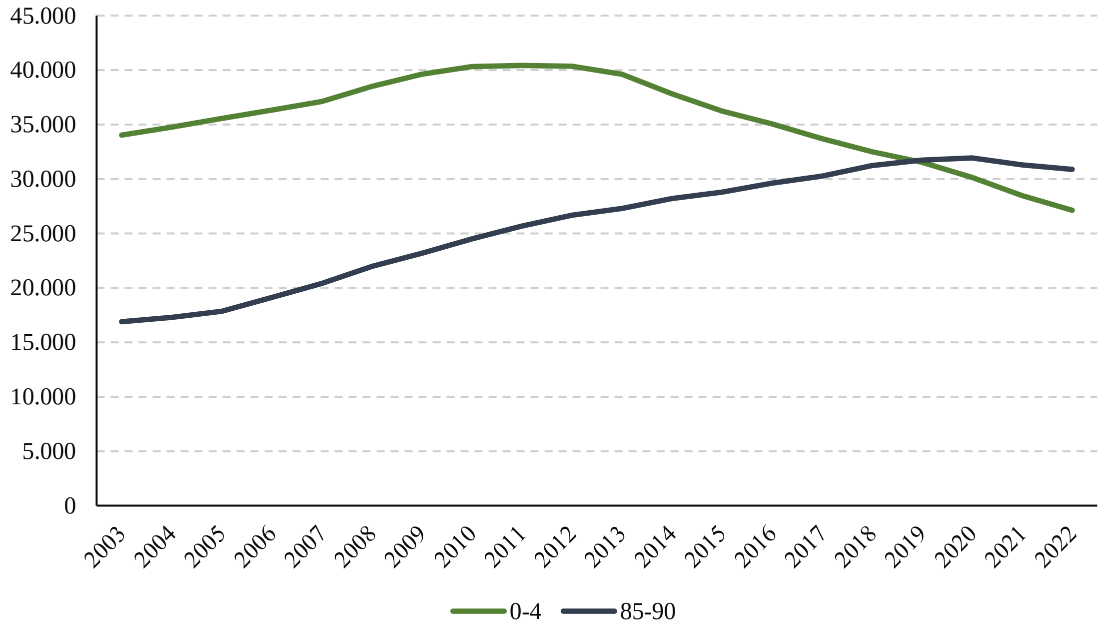
*Figure V: Evolution of the total population in the Principality of Asturias, 2002-2022*




*Source: Own elaboration based on data by INE, 2023*

Regarding population aging, Figure VI shows the number of inhabitants between 0 to 4 and 84 to 89 years old. As can be observed, the latter group surpassed the former in 2019, maintaining this trend until the present. These results align with the increase in life expectancy and the decrease in birth rates observed in developed countries since the second half of the 20th century. However, when considering the case of Asturias, distinguishing between the different areas of the region is of particular interest.

*Figure VI: Number of inhabitants aged 0 to 4 and 85 to 89 years old*




*Source: Own elaboration based on data by INE, 2023*

The Autonomous Community of the Principality of Asturias is divided into 78 councils, which is the name traditionally used for municipalities in the region. Even though the population figures are generally alarming all across the region, and as is the case in Spain, the severity of the situation varies significantly from one region to another. In general, the risk of depopulation is frequently related to the territory's productive capacity and the available job opportunities (Pašić et al., 2010; Pinilla & Sáez, 2017; Almeida, 2018). In the case of Asturias, the region's productive capacity is notably unevenly distributed, and so is employment. This has a strong connection with territory's mining history, mainly during the 20$^{th}$ and early 21$^{st}$ centuries. The first mining shafts were opened in the region at the beginning of the 20th century. Since then, the sector developed into the main economic activity in several councils. In these early stages, those areas with the largest coal reserves witnessed how numerous companies, sometimes owned by foreign investors, started to set up in the territory and began the extractive activity. This boosted the labor supply, which in turn led to a sharp increase in emigration, mainly from other regions of Spain, but also within the region itself. The rapid growth experienced during those early years contrasts with the current magnitude of depopulation in these areas.

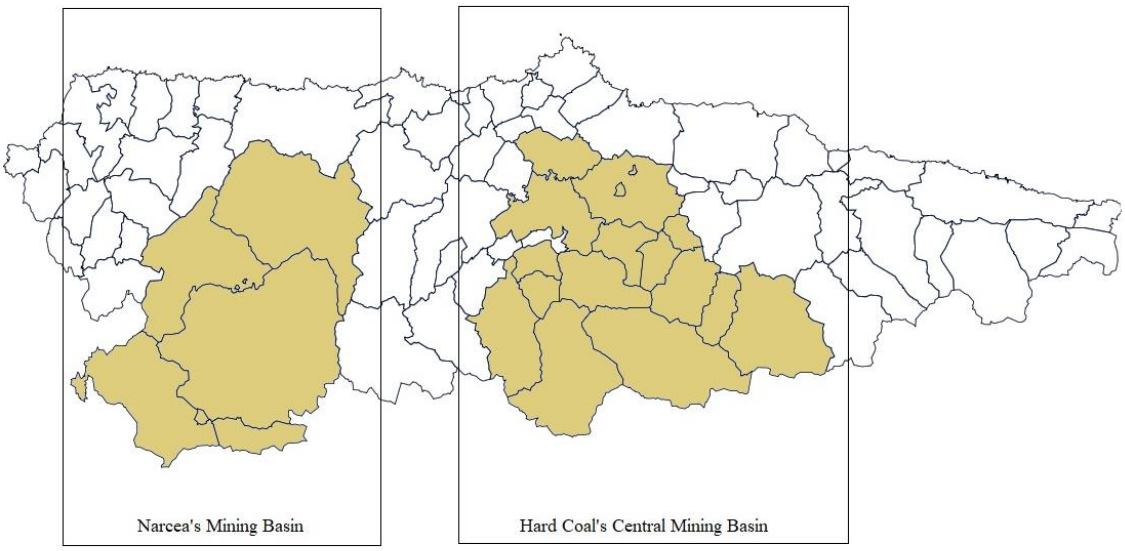
Ten councils form the so-called “Cuenca Minera Asturiana” (Asturian Central Mining Basin). According to the latest INE figures (2023), of their 134,795 inhabitants, only 11,023, 10%, are under 15 years old. In some of them, such as Caso, the situation is even more dramatic and 48.83% of its inhabitants are over 65 years old. Although the decline of the Asturian mining sector began in the mid-twentieth century, it was not until the mid-1990s that its effects became visible in the structure and characteristics of the population. Indeed, 1996 population figures raised serious concerns in the region. Until then, population levels had remained relatively stable; however, the population started to fall dramatically that year. In 2000, 174,584 people lived in the territory, whereas today there are 133,207, 23.7% less. In addition to the evident industrial crisis, the mining areas have lower birth and higher emigration rates, either compared to other areas of Asturias, Spain or even abroad. From 2000 to 2020, during the two decades in which practically all the mine closures in the region took place, and in which the mining sector went from having 7500 workers to barely 700, the area experienced a reduction of 41,377 inhabitants. That is to say, 71% of the demographic fall of Asturias corresponds to the mining valleys. In order to offer a more in-depth explanation of the relationship between mining and the demographic situation of the region, the following sections will attempt, first, to identify and contextualize the situation of the main affected councils and, second, to analyze the real weight that the mining sector had on their economies.

## 3. The weight of mining in the Asturian economy

Asturias is one of the Spanish regions with the oldest industrial tradition, mainly because of its extensive hard coal deposits, which were a crucial location factor for steel companies until the late 20th century. However, and even though these two activities, mining and the iron and steel industry, are two key pillars of the Asturian industrialization process, they involve very contrasting realities. In fact, for each of the two largest factories that controlled the territory in the two main river and mining basins, the Nalón and the Caudal ones, the number of coal mines is much higher and, therefore, the labor supply of mining was much greater than that of the steel industry (Suárez, 2005). As a consequence, the end of the economic cycle based on coal, materialized in the closure of mining and the dismantling of the steel industry, lead these territories to a severe crisis. From this point on, those production areas where the main extractive industry was concentrated were immersed in a deep decline in several aspects. As the most direct consequence, the loss of their main industrial activity initially resulted in high unemployment rates. Nevertheless, during the following stages, the harsh conditions that the population was suffering because of the lack of opportunities lead also to an accentuation of the migratory process, which ultimately triggered the beginning of a great population loss.

In order to justify the possible impact of the closure of the mining sector in the region, the first phase of the analysis aims to quantify the real importance of the extractive industry in the Principality of Asturias. For this, the first step has been to identify the areas where there are or were active deposits. Figure VII shows the two river basins that concentrate coal mining in Asturias, and the councils in which they are located. The first one, the Narcea Basin, is located in the west and it was where anthracite was extracted. Although it is of economic importance for the area, large production zones were never formed, and it was limited to small and medium-sized mountain exploitations. Because of this, the analysis is not focused on the consequences for this area. On the contrary, the second and most important basin, the Central Coal Basin, is the subject of the study. There, hard coal was extracted, and the exploitations were much larger, which led to early industrialization and a strongly urbanized area.

*Figure VII: Mining basins in Asturias*




*Source: Own elaboration*

Although the literature mentions peripheral and ultraperipheral spaces that would also have been affected, and which are also shown in Figure VII, the extractive activity was not as important in every council. As for the selected “Mining councils”, the procedure followed has been to identify those with the largest number of mine shafts. According to this, the selected councils are those that occupy the central space of the Central Mining Basin: Langreo, Aller, Mieres, and San Martín del Rey Aurelio[4]. In addition to their geographical position, these councils would have suffered a more intense and direct effect of mining, first because of its boom and later because of its decline. In order to quantify both the impact and the extent to which mining had a significant weight in each selected council’s economies, I have first sought information on the shafts that were operational in each municipality during the 20th century, their opening and closing dates, and their date of incorporation into HUNOSA (Hulleras del Norte S.A.), a public company founded in 1967 by the Institute of Industry during Franco's regime. These data are summarized in Table I.

*Table I: Mine shafts per selected council. Dates of opening, incorporation to HUNOSA, and closure*

| COUNCIL | Mine shafts | Opening | HUNOSA | Closure |
|---|---|---|---|---|
| Aller | San Antonio | 1942 | 1967 | 2003 |
| | San Jorge | 1940 | 1967 | 2018 |
| | San Fernando | 1942 | 1967 | 1968 |
| Langreo | San Luís | 1928 | 1968 | 2002 |
| | María Luisa | 1943 | 1967 | 2016 |
| | Fondón | 1917 | 1967 | 1995 |
| | Modesta | 1910 | 1967 | 2007 |
| | Samuño | 1925 | 1967 | 2001 |
| | Lláscares | 1930 | 1969 | 2013 |
| | Candín | 1933 | 1967 | 2012 |
| | Terrerrón | 1926 | 1967 | 1989 |
| Mieres | Nicolasa | 1880 | 1967 | Open |
| | Santa Bárbara | 1913 | 1970 | 1995 |
| | Polio | 1953 | 1967 | 1991 |
| | Barredo | 1926 | 1967 | 1995 |
| | Figaredo | 1902 | 1967 | 2007 |
| | San José | 1957 | 1968 | 1993 |
| | Espinos | 1927 | 1967 | 1967 |
| | Tres Amigos | 1942 | 1969 | 2000 |
| | Llamas | 1941 | 1967 | 1970 |

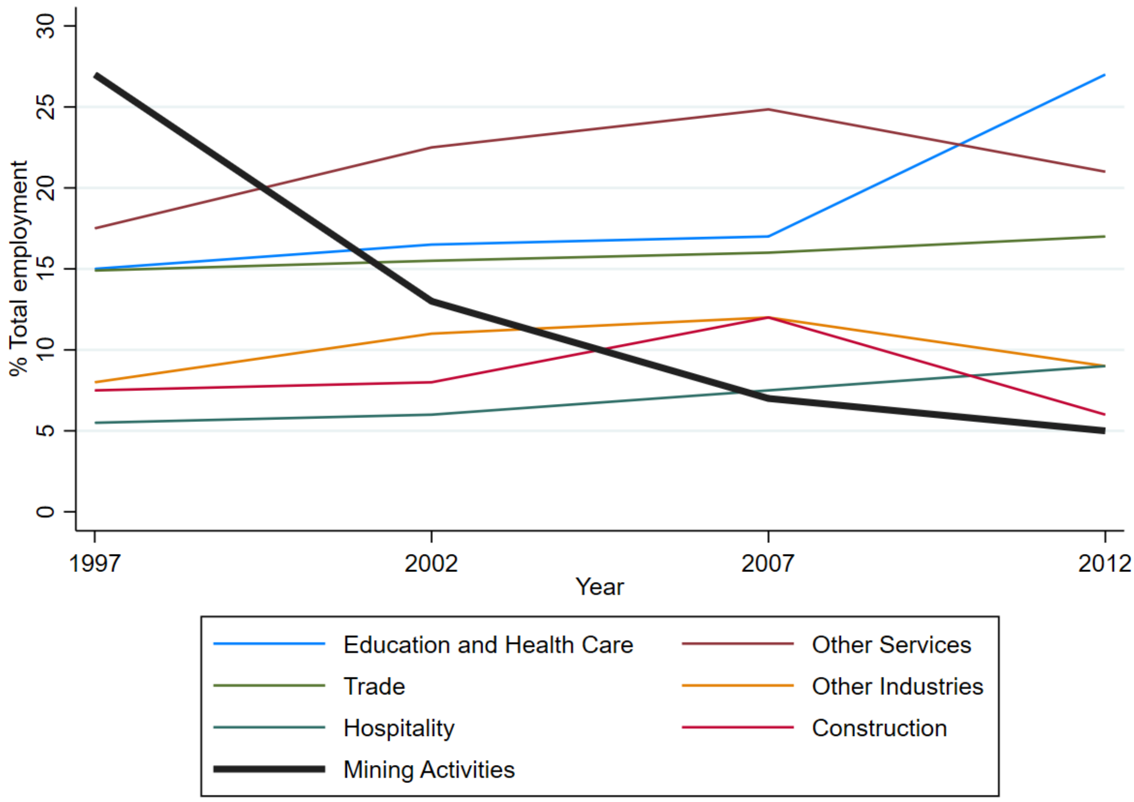
[4] *The acronym SMRA will be used throughout the text.*

| | | | | |
|---|---|---|---|---|
| SMRA | Sotón | 1922 | 1967 | 2014 |
| | Venturo | 1964 | 1967 | 1990 |
| | San Mamés | 1940 | 1967 | 1992 |
| | Sorriego | 1920 | 1969 | 1978 |
| | El Entrego | 1917 | 1970 | 1993 |
| | Cerezal | 1942 | 1967 | 1988 |
| | San Vicente | 1916 | 1970 | 1998 |

*Source: Patrimoniu Industrial, 2019*

In the early 1960s, the costs of mining coal began to grow faster than revenues, so that profit margins declined sharply, and many smaller companies were forced to close, while larger ones began to reduce their workforces. Because of this, and in an attempt to save the situation, the government tried to rescue the mining sector by creating HUNOSA in 1967, 77% of whose capital belonged to the National Industry Institute, while the rest was diversified in 8 other medium-sized companies (HUNOSA's historical archive, 2018). At the time of their creation, the mining companies had a total workforce of 20,017 workers and a production of 3,145,140 tons (Santullano, 1998). In addition, I have also collected information on some indicators that can give a general idea of the importance of mining in each municipality. However, this information was highly atomized until the creation of HUNOSA and the unification of the mining industry since almost every shaft belonged to a different company. As it has been previously mentioned, from 1960 onwards, a few years before HUNOSA was created, the economy of the Asturian coalfields entered a deep recession determined by the definitive and structural crisis of the mining industry. Between 1960 and 1973, coal production fell from 7.8 million tons per year to 4.8 million tons, while the volume of employment dropped from 45,500 to 28,350 workers (Fernández, 1989). In 1975 there was a slight increase with 5.4 million tons and 1,360 more workers. However, in 1986 production fell again to 3.6 million tons and 21,000 workers, and in 1990 there were 3.1 million tons and 18,250 jobs. Even so, in 1985, the service sector in the Central Coal Basin accounted for 67.6% of GDP due to mining activity (66% of the sector's GVA), well above the national average (Santullano, 1998). As for specific information on each of the selected councils, some data exist that help to get an idea of the impact that the decline of mining had on them. In the case of Aller, in 1986, 55% of the working population was employed in the mining sector and HUNOSA's share of employees' salaries represents 77% of total wages in the municipality. Nowadays, most of the council's pensioners come from the mining industry (Álvarez, 1986). Regarding Langreo, 34.59% of its working population in 1986 was employed in mining and derivatives (Pérez, 1993). As for Mieres, 68% of its population was employed in 1988, 56.3% in the secondary sector and 45.5% of those in the mining sector. However, just 56% of its population was employed in 1988, which assumes a loss of 3,327 jobs (García & Gutierrez, 1988). Lastly, and following a similar path, 47.7% of the population of San Martín del Rey Aurelio in 1986 was employed in the mining industry (Rodriguez, 1989). In this regard, Figure VIII provides a general picture of the declining importance of the mining sector in employment in the councils forming the Central Mine Basin. In 1997, more than 25% of the population living in that area was employed in mining activities. However, the same percentage dropped to 5% in 2012, just fifteen years later.

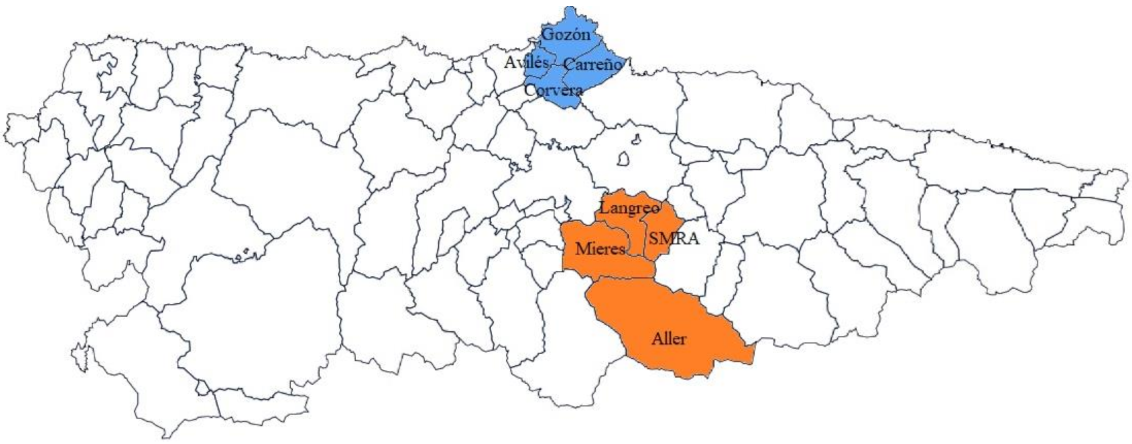
*Figure VIII: Jobs percentage by sector selection in the Central Mining Basin 1997-2014*




*Source: Own elaboration using data from SADEI (2014)*

Following the approach of the study, the second step was to find a comparison group within the Asturian region. For this, another four councils not directly affected by the mining industry, and whose economies were not completely dependent on coal, were selected and identified as “Non-Mining” councils. They are Avilés, Carreño, Corvera and Gozón, and its geographical location can be seen in Figure IX, and the so-called “mining councils”. Its main economic activity was based on the iron and steel industry and, although both sectors are in a sense interrelated, the importance of mining in this area of Asturias was much lower than in the rest of the region. The selected “Non-Mining” councils thus serve as the closest possible unit of comparison to the mining councils, but without the extractive activity being crucial for their economic performance.

*Figure IX: Selected “mining” and “non-mining” councils*




*Source: Own elaboration*

After this first step of acknowledging the relevance of the mining industry in Asturias and identifying the main mining areas, as well as the comparison group where mining was not as important, the next sections are focused on the evolution of the population trends in parallel to the situation in the mining sector. The empirical analysis is divided into three different but interconnected parts. The first one is a long-term historical and descriptive analysis, which uses data on total population and population density from 1900 to the present and analyses how these trends evolved through time. The second one is a short-term econometrics analysis that is in turn divided into two parts. The first seeks to find the relationship between demographic and socioeconomic factors, while the second attempts to determine whether there is any correlation between the socioeconomic factors identified as determinants of the population decline and the relationship of each council with mining. Lastly, using the years in which the mines were closed, the synthetic controls method is applied to observe the extent to which these shocks affected the trend of the selected demographic and socioeconomic factors.

## 4. The empirical analysis

### 4.1. The hypothesis

The study's main hypothesis is that the closure of the mines in Asturias had a negative effect on the population levels of the affected councils. While it is true that the population has been declining in the entire region for decades, the present analysis attempts to prove how the closure of the mines caused this population decline to be faster and more accentuated in the selected councils than it would have been if the mining sector had maintained its activity.

### 4.2. The data

The first problem, and perhaps to some extent limitation of the study, arises when collecting the data. First, it is important to differentiate between the two types of panel data used in the analysis: demographic and socioeconomic. Within the first group, disaggregated information is available at the council level from 1900 to the present. I have collected information from the Asturian Society of Economics and Industrial Studies (SADEI) on total population levels from censuses and registers on each of the selected councils. Then, I calculated each council's population density using information about the council's size and constructed a database gathering both variables. From 1900 to 1990, data are available every 10 years and, from 1991 onwards, annually. Table II displays the descriptive statistics of this first database.

*Table II: Descriptive Statistics of demographic variables*

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| council | 3198 | | | | |
| year | 3198 | 1991 | | 1900 | 2022 |
| totalpop | 3198 | 26,325 | 120,433 | 128 | 1,129,556 |
| popdensity | 3198 | 142.937 | 379.792 | 2.719 | 3,314.373 |

Regarding the socioeconomic information, disaggregated data are only available from 2001 onwards. Thus, I constructed another database combining the data gathered from different reports published by the National Institute of Statistics of Spain (INE) and the Asturian Institute of Socioeconomic Studies (SADEI). Some of the variables needed for the analysis were not available and are from own construction. They are based on calculations using alternative available information. It is the case of the emigrants and immigrants ratios, and the variables accounting for unemployment rates, total, male and female. Descriptive statistics of these second database are displayed in the following Table III. It contains information on 78 councils from 2001 to 2022. However, data are not continuously available for all variables. Following the order in which they are presented in the table, the indicators that are used in this part of the analysis are: the total unemployment rate, as well as both male and female unemployment rates; the percentage of emigrants and immigrants over the total population, the number of educational centers in each council offering “bachillerato[5]”, the rate of foreigners, the average age of the population, the dependency rate; the Gross Value Added per capita, which is used as a proxy for the Gross Domestic Product per capita; the Crude Birth and Death Rates; the Natural Increase Rate; the Crude Marriage Rate, and the Gross Migration Rate.

*Table III: Descriptive Statistics of selected socioeconomic variables*

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| council | 3239 | | | | |
| year | 3239 | 1991 | | 2001 | 2022 |
| totalun | 1738 | 8.493 | 3.28 | 2.151 | 20.106 |
| maleun | 1738 | 8.06 | 3.554 | 1.402 | 20.909 |
| femaleun | 1738 | 8.946 | 3.434 | 0 | 20.253 |
| emigrants | 1659 | 1.003 | .603 | 0 | 4.727 |
| immigrants | 1659 | 1.239 | .767 | 0 | 6.445 |
| bachiller | 1185 | 2.488 | 11.331 | 0 | 99 |
| foreignrate | 1738 | 2.445 | 1.69 | 0 | 13.04 |
| averageage | 1738 | 49.507 | 3.802 | 39.2 | 59.84 |
| dependencyratio | 1738 | 63.314 | 11.39 | 35.74 | 101.94 |
| GVApc | 633 | 1,318.344 | 806.604 | 314.314 | 5,795.173 |
| CBR | 1661 | 329.398 | 166.2 | 1 | 657 |
| CDR | 1661 | 433.302 | 258.851 | 1 | 960 |
| NIR | 1661 | 564.303 | 333.556 | 1 | 1097 |
| CMR | 1661 | 227.063 | 116.787 | 1 | 485 |
| GMR | 1661 | 561.117 | 331.207 | 1 | 1128 |

[5] Bachillerato is the required level of education in Spain to access university studies.

### 4.2.1. Limitations

It may be considered that the preciseness of the results presented in the following sections, and therefore its interpretation, are subjected to the limitations of the data. As it has been previously mentioned, there is no continuous socioeconomic information available disaggregated by council until 2001. In addition, some of the variables are of own construction, created from calculations based on alternative available information. This is the case of the ratios of emigrants and immigrants, and the total, male and female unemployment rates. However, in the case of this latter variables, they are fundamental for the analysis, and its estimations could compromise the accuracy of the results. Similarly, another variable whose interpretation is essential for the study is the Gross Value Added per capita. It is used as a proxy for the Gross Domestic Product per capita, however, significant differences between both values could also influence the final outcome of the analysis.

## 4.3. Methodology

To some extent, the limitation caused by the absence of continuous and harmonized information on the two types of data used, demographic and socioeconomic, compromises the structure of the analysis and conditions the different types of methodology used. Because it is not possible to merge the two databases due to the significant difference in the periods that both cover, I divided the analysis into different steps. The first one follows a more long-term historical and descriptive approach, where the demographic data are used to analyze the evolution of the total population and population density levels through the $20^{th}$ and $21^{st}$ centuries.

The second one is a short-term econometrics analysis that is in turn divided into two parts. The first one seeks to find the relationship between demographic and socioeconomic factors. For this, the three following multiple linear regression models (1), (2) and (3) are estimated using OLS.

$$emigrants_i = F(\beta_0 + \beta_1 totalun_{it} + \beta_2 dependencyratio_{it} + \beta_3 bachiller_{it} + \beta_4 GVApc_{it} + \beta_5 CMR_{it} + \beta_6 averageage_{it} + \varepsilon_i) \quad (1)$$

$$CBR_i = F(\beta_0 + \beta_1 totalun_{it} + \beta_2 dependencyratio_{it} + \beta_3 bachiller_{it} + \beta_4 GVApc_{it} + \beta_5 CMR_{it} + \beta_6 averageage_{it} + \varepsilon_i) \quad (2)$$

$$immigrants_i = F(\beta_0 + \beta_1 totalun_{it} + \beta_2 bachiller_{it} + \beta_3 GVApc_{it} + \varepsilon_i) \quad (3)$$

The second part attempts to determine whether there is any correlation between the socioeconomic factors identified as determinants of the population decline from the previous models and the relationship of each council with mining. For this, I divided the already selected councils into three different categories according to their relationship with mining during the period from 2001 to 2022. Those councils in which mining never had a significant weight, and which had been previously identified as a comparison group, are categorized as "Non-Mining", while those in which the majority of mining shafts were closed prior to the study period are categorized as "Ex-Mining". Finally, those councils in which most shafts were closed during the study period are categorized as "Mining". I have also created a dummy variable to account for the years in which a shaft was closed in order to identify if that kind of shock had an impact on the council in terms of unemployment or production. To perform this analysis, the following models (4) and (5) are applied and also estimated using OLS.

$$totalun = F(\beta_0 + \beta_1 minestatus_{it} + \beta_2 closure_{it} + \beta_3 emigrants_{it} + \beta_4 averageage_{it} + \beta_5 CMR_{it}) \quad (4)$$

$$GVApc = F(\beta_0 + \beta_1 minestatus_{it} + \beta_2 closure_{it} + \beta_3 emigrants_{it} + \beta_4 averageage_{it} + \beta_5 CMR_{it}) \quad (5)$$

Lastly, observing the dates on which the mines that were still active after 2001 were closed, the year 2012 is taken as a reference to estimate the effect of the closure of the mining sector on population levels. The methodology applied is based on the synthetic control's theory for this last part of the analysis. In this approach, introduced by Abadie and Gardeazabal (2003) and Abadie et al. (2010), the units in the control group are weighted to construct a synthetic counterfactual that replicates the initial conditions and the potential population levels of the councils of interest before the mine closures. The synthetic control of "donors" is created so that the averages of the synthetic total population levels and their determinant variables closely match the corresponding figures of the selected mining councils during the pre-intervention period, in this case, the period prior to the closure of the mining sector. Ultimately, this allows to discern the extent to which this shock affected the trend of the selected demographic and socioeconomic factors.

### 4.3.1. The synthetic control method

Framing the problem in the context of the present study, Y is the outcome of interest, the realization of which depends on the closure of the mining sector. In particular, the realization in a given council during year *t* is equal to $Y_t^1$ if the region is exposed to a mine closure and $Y_t^0$ otherwise,

$$Y_t = C_t Y_t^1 + (1 - C_t) Y_t^0,$$

where $C_t$ is an indicator for mine closure in such council. The identification problem is that the treatment effect of the closure of the mining sector,

$$\beta_t = Y_t^1 - Y_t^0 \ ,$$

depends on the potential outcome in both $C_t = 0$ and $C_t = 1$, while only one can be observed in any given year.

Here, the synthetic control method exploits the variation over time in the outcomes of councils that are exposed to treatment only after some period $t = T$ or never exposed. The estimator then compares the actual outcome in the treated council with the weighted average of all units in the control group,

$$\hat{\beta}_t = Y_t - \sum_{i \epsilon I} w_i \, Y_{it},$$

where $w_i$ is the weight enclosed to each council *i* in the control group *I*. However, since the treated and the control councils are observed in different states after *T*, with and without the shock of the closure of the mines, the expression becomes

$$\hat{\beta}_t = Y_t^1 - \sum_{i \epsilon I} w_i \, Y_{it}^0 = \beta_t + \left( Y_t^0 - \sum_{i \epsilon I} w_i \, Y_{it}^0 \right), \forall t > T^0$$

Hence, the accuracy of $\hat{\beta}_t$ as an estimate of $\beta_t$ depends on the difference between the treated and control councils over the period in which none of them were exposed to the treatment, this is, before *T*. As long as the given weights reflect structural parameters that would not vary in the absence of the closure of the mining sector, the synthetic control approximates the unobserved counterfactual trend of the potential outcome $Y_t^0$ after *T*. Regarding the divergences between synthetic controls and difference-in-difference models, Abadie et al. (2010) find that synthetic controls allow the effect of the unobserved confounders to vary over time consistent with a flexible factor representation of the potential outcomes of council *i*.

## 5. The results

### 5.1. The long-term analysis: a historical description

In this first part of the analysis, the evolution of population levels in Asturias is analysed from a more historical perspective, using the available data from 1900 to the present time. In order to show its evolution through time, I have first divided the time span into three distinct periods and then calculated the variation in population levels in both groups of councils, the results of which can be seen in Table IV. The first period takes the first population data in the year 1900, coinciding with the beginning of the mining activity in most of the study areas, and compares them with those of the year 1960, the decade in which HUNOSA was created and the mining sector was already in decline. In this first period, it can be observed that the percentage increase in population is significantly higher in the so-called Mining councils compared to the Non-Mining ones, and even tripled its population. The second period takes as a reference the population in 1960 and calculates the percentage variation with respect to 1990, the decade in which the first mine closures began. In contrast to the first one, in this second period the Mining councils suffer significant drops in the percentage variation of the population, much greater than those of the Non-Mining councils. In the case of the latter, the population even continues to grow in some of them. Lastly, in the third period, the population in 1990 is taken as a reference and compared with the latest available data for 2022. In line with the second period of study, the percentage variation of the population suffers notably larger drops in the Mining councils. However, in the latter case, the population also decreases in most of the Non-Mining ones, which would be in line with the latest reports that point to a generalized loss of population in the Asturian region.

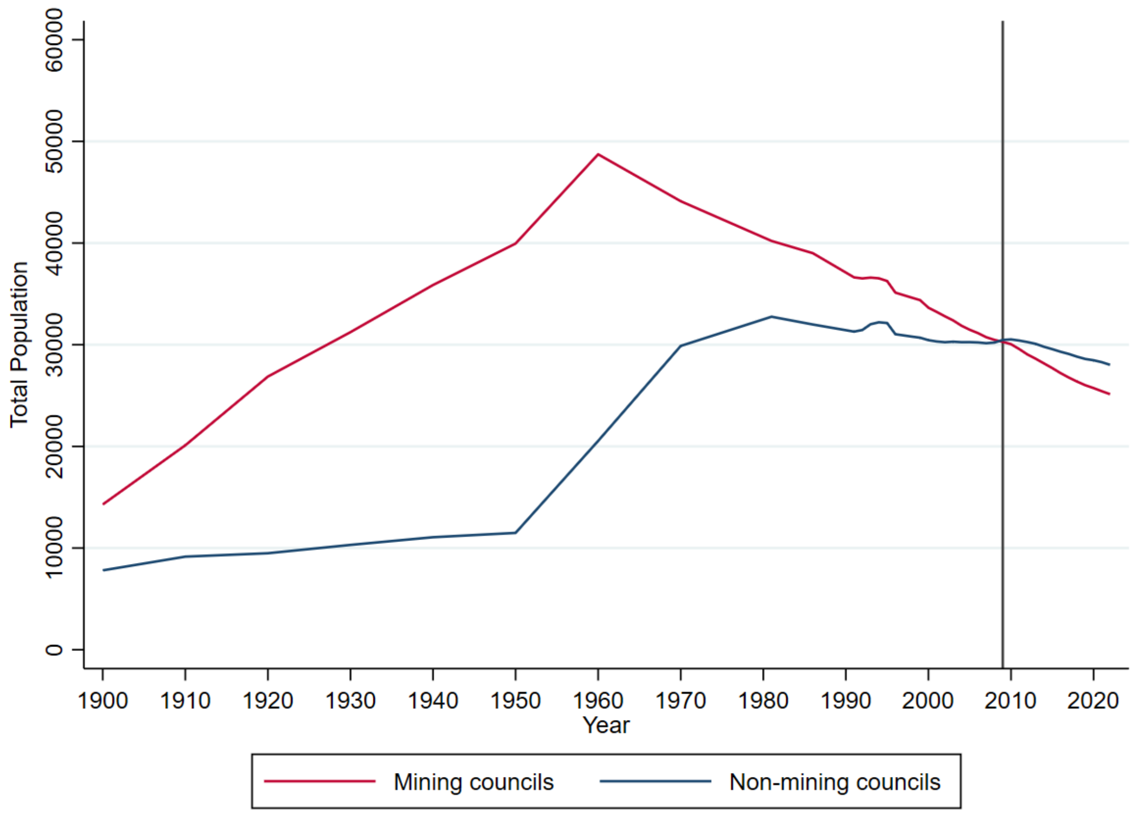
*Table IV: Percentage variation in total population 1900-1960, 1960-1990, 1990-2022*

| | 1900 | 1960 | Δ% | 1990 | Δ% | 2022 | Δ% |
|---|---|---|---|---|---|---|---|
| **Mining councils** | | | | | | | |
| Aller | 12938 | 29449 | 127.62 | 17538 | -40.45 | 10201 | -41.83 |
| Langreo | 18751 | 66323 | 253.70 | 51710 | -22.03 | 38262 | -26.01 |
| Mieres | 17867 | 71092 | 297.90 | 53482 | -24.77 | 36574 | -31.61 |
| SMRA | 7602 | 28051 | 269.00 | 23765 | -15.28 | 15505 | -34.76 |
| **Non-mining councils** | | | | | | | |
| Avilés | 12674 | 48620 | 283.62 | 85351 | 75.55 | 75877 | -11.10 |
| Carreño | 7487 | 11213 | 49.77 | 11062 | -1.35 | 10226 | -7.56 |
| Corvera | 4045 | 9851 | 143.54 | 11570 | -7.29 | 15563 | 34.51 |
| Gozón | 7030 | 12480 | 77.52 | 17167 | 74.27 | 10433 | -39.23 |

*Source: Own elaboration*

Moreover, I have also calculated the average population over time for each group of councils, Mining and Non-Mining. By plotting these data on a graph, the image supports the hypothesis that the closure of mining in the councils where this sector had a very important weight in the economy meant that the impact in terms of population loss was greater in those areas. Figure X describes the total population trend followed by both groups of selected councils. At the beginning of the series, the Mining councils had a slightly higher population than the Non-Mining councils. This trend would become more noticeable until the 1950s. From then on, the population continued to grow in these areas, and significantly among the so-called Non-Mining councils. In this sense, the early 1960s were a turning point. The population of the Mining councils began to fall, coinciding with the decline of the mining sector and the subsequent creation of HUNOSA, and it does so practically continuously until the present day. However, the 1960s were a period of growth in terms of population for the group of selected Non-Mining councils. In their case, the levels increase until the 1980s, when they also begin to fall, although in a much more sustained manner than in the first group. Finally, in 2009, the average total population levels of the Non-Mining councils exceeded those of the Mining councils for the first time, and have continued to do so up to the present even though the decline in population in those areas also continues to this day.

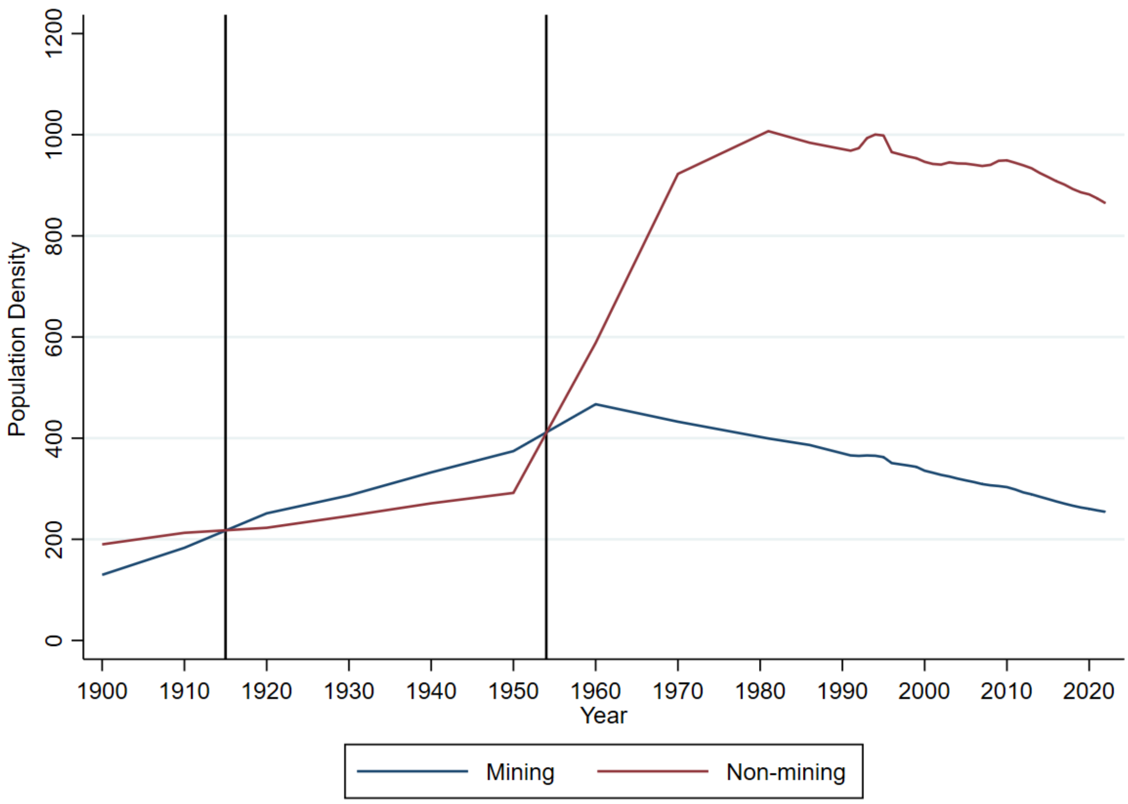
*Figure X: Total Population Evolution Mining and Non-mining Councils*




*Source: Own elaboration using data from SADEI*

In order to provide a more accurate picture of the situation, I repeated the same procedure as above, however, this time using population density levels instead of total population. Here, Figure XI shows a picture that is more in line with the reality of the history of Asturias and supports the initial hypothesis about the impact of the mining closure on the region. The first thing to note is how using population density data, this was higher in the so-called Non-Mining councils. However, the first shift occurs in the mid-1910s, a date that coincides with the opening of numerous mining shafts and from which population density begins to be higher in the Mining councils. This trend continued until the mid-1950s although the difference between the two groups remained small. However, at the beginning of the 1950s, the population density levels of the Non-Mining councils began to grow significantly, which meant that by the mid-1950s they were already higher than those of the Mining councils. Beyond this, the figures begin to fall in the latter group in 1960, once again the decade in which the decline of the sector becomes more noticeable, the first shaft closures take place and the company HUNOSA is created in an attempt to preserve the mines, which were already loss-making. From then on, the differences in population density between the two groups became more evident, since the levels continued to rise in the Non-Mining councils until 1980. Thereafter, the decline is also noticeable in this group, but the fall continues to be greater among the Mining councils, which has led to the current situation where this large gap remains still present.

*Figure XI: Population Density Evolution Mining and Non-mining Councils*




*Source: Own elaboration using data from SADEI*

However, when it comes to studying the determinants of this significant population loss, it is not just the massive migration as a result of the lack of opportunities in the historically identified mining areas, but also the significant fall in birth rates that followed the years after the closure of the mines. As for how the lack of job opportunities affects fertility rates, there is an extensive literature on the effect that these types of socioeconomic factors can have (Adsera, 2005; Sobotka et al., 2011; Currie, 2014; Bono, 2015; Fernandez-Crehuet, 2020; Andersen, 2021). In line with this, in the following section, an econometric analysis is carried out to try to establish these causal links between the cessation of mining activity and the impact at the socioeconomic level in those areas where it was the main activity.

## 5.2. The short-term analysis: a causal explanation

### 5.2.1. The relationship between demographic and socioeconomic factors

The second part of the analysis aims to provide a causal explanation to the historical argument and the trends in population levels that have been presented in the previous section. In order to do this, the analysis resorts to the literature that relates population growth to socioeconomic characteristics such as migration (Bilsborrow, 1992; Glomm, 1992; Barro & Sala-i-Martin, 1992; Johnson, 2003) and fertility (Lam, 1986; Becker, 1992; Craig, 1994; Bongaarts, 2009; Bongaarts, 2015). For that, I ran the previously presented models (1), (2) and (3), the results of which can be found in the following Table V. The first column collects the coefficients of Model 1, which uses the emigrant ratio as the dependent variable. As for the independent variables, total unemployment, the dependency ratio, the number of centers offering bachillerato, the Crude Marriage Rate and the Gross Value Added per capita are used, the latter variable being used as a proxy for Gross Domestic Product per capita. According to the estimations, the total unemployment rate, the GVA per capita, and the marriage rate would significantly affect the rate of emigrants. According to the signs of the coefficients, higher levels of unemployment would be correlated with higher levels of emigration. On the contrary, higher levels of GVA per capita and the marriage rate would lead to lower emigration.

In the case of Model 2, it uses the Crude Birth Rate as the dependent variable and, as in the previous model, the total unemployment rate, the dependency ratio, the number of educational centers offering bachillerato, the GVA per capita and the Crude Marriage Rate as the independent ones. According to the results, all of them but the number of centers offering bachillerato would significantly affect fertility. Disentangling the effect of each variable, higher levels of unemployment would imply lower fertility rates, a similar effect to that of the dependency ratio. However, higher GVA per capita levels and marriage rates would be correlated with higher fertility.

Lastly, Model 3 uses immigration as the dependent variable and studies the effect that unemployment, the population's average age, the accessibility to bachillerato studies, and the GVA per capita have on it. According to the results, higher unemployment and average age would be correlated with less immigration, while higher levels of GAV per capita would attract it. Regarding the number of centers offering bachillerato in the council, the estimation coefficients remain significant throughout the three models.

*Table V: Correlation between the selected independent socioeconomic variables and emigration, immigration, and fertility*

| VARIABLES | (1)<br>emigrants | (2)<br>CBR | (3)<br>immigrants |
|---|---|---|---|
| totalun | 0.0238*** | -3.970** | -0.0465*** |
| | (0.00658) | (1.717) | (0.00851) |
| dependencyratio | 0.00106 | -3.995*** | |
| | (0.00404) | (0.864) | |
| bachiller | 0.00350 | 1.207 | 0.00292 |
| | (0.00508) | (0.833) | (0.00595) |
| GVApc | -0.0102** | 0.0421*** | 0.0381** |
| | (0.0599) | (0.0111) | (7.12e-05) |
| CMR | -0.0314* | 0.354*** | |
| | (0.000245) | (0.0644) | |
| averageage | | | -0.0489*** |
| | | | (0.0158) |
| Constant | 0.709** | 413.6*** | 4.058*** |
| | (0.297) | (66.78) | (0.787) |
| Observations | 475 | 475 | 475 |
| Number of council | 78 | 78 | 78 |
| Adj R-Squared | 0.5817 | 0.6157 | 0.5791 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

After running the previous models, it is possible to draw two main conclusions. First, since the coefficient of total unemployment is maintained throughout the three models with a high level of significance, it is possible to affirm that this is a factor that would be notably affecting the demographic characteristics of the Asturian population. Second, the Gross Value Added per capita, which is used as a proxy for the Gross

Domestic Product per capita, also maintains a significant impact on the three dependent variables used, therefore it also suggests a possible correlation with the demographic characteristics. However, it remains crucial to the analysis the way in which these two identified factors, the total unemployment rate and the Gross Value Added per capita, are affected by the weight of the mining sector. These are the mechanisms through which this relationship takes place, which will be explored in the next section.

### 5.2.2. The relationship between the identified socioeconomic factors and council status

Having identified the factors that most notably affect the demographic characteristics of the Asturian population, the next step is to understand the relationship between these socioeconomic factors and the status of each council in question. That is, to analyze whether a council is "Miner" or not, according to the categorization used, is related to the factors previously identified as determinants of the population's demographic characteristics. As it has been mentioned, I created three new variables in order to perform this test, each of them accounting for the status of the council in relation to mining. I also created a dummy variable accounting for the years in which a mine shaft closure took place. Table VI shows the results of the coefficients after estimating models (4) and (5). The first two columns indicate that have been a Mining council before 2001 is correlated with higher unemployment rate and lower levels of GVA per capita. Regarding the effect of the year of closure of the mining shafts, it proves to have a significant effect when it comes to the total unemployment rate, however, the coefficient is not significant for the GVA per capita. The third and fourth columns show how having mine shafts still operating after 2001 is also correlated with higher levels of unemployment in the council; however, this time there is no significant effect in the relationship between councils with this status and the GVA per capita. Lastly, columns 5 and 6 show the positive effect that had not had a mining-based economy has on employment, being this status strongly correlated with lower levels of unemployment. In a similar line, the Non-Mining council status is also correlated with higher values of GVA per capita.

*Table VI: Correlation between being an Ex-Mining, Mining or Non-Mining council and the total unemployment rate and the GVA per capita*

| VARIABLES | (4) totalun | (5) GVApc | (4) totalun | (5) GVApc | (4) totalun | (5) GVApc |
|---|---|---|---|---|---|---|
| EX_MINE_COUNCIL | 4.720*** | -376.8* | | | | |
| | (1.317) | (203.9) | | | | |
| MINE_COUNCIL | | | 3.516** | -190.9 | | |
| | | | (1.365) | (553.5) | | |
| NO_MINE_COUNCIL | | | | | -4.227*** | 290.9** |
| | | | | | (0.899) | (146.0) |
| closure | 0.254** | 67.39 | | | | |
| | (0.224) | (96.86) | | | | |
| Constant | 8.351*** | 1,319*** | 8.404*** | 1,324*** | 12.51*** | 1,042*** |
| | (0.211) | (34.60) | (0.217) | (88.07) | (0.876) | (142.3) |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1,738 | 633 | 1,738 | 633 | 1,738 | 633 |
| Number of council | 78 | 78 | 78 | 78 | 78 | 78 |

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Summarizing the results of the tests, it is possible to conclude that, in general, the status of each council concerning the mining sector influences its levels of total unemployment and GVA per capita, which were the two main variables that were found significant when exploring the determinants of the current demographic characteristics of the Asturian population. As for the direction of these relationships, it can be stated that have or had have a mining-based economy is correlated with both higher levels of unemployment and lower levels of GVA per capita, the variable that has been used as a proxy for GDP per capita, while not having had an economy based on the mining sector is correlated with both lower unemployment levels and higher GVA per capita. Therefore, when taking these results into account, it becomes clearer that the observed impact that socioeconomic characteristics have on the demographic conditions of the population occurs through the specific status of each council. This is, being a Non-Mining, Ex-Mining, or currently Mining council is affecting total unemployment and GVA per capita levels, and therefore the demographic characteristics of the population in each council, which, as it has been observed, are usually a sharper population decline, in both absolute and relative terms.

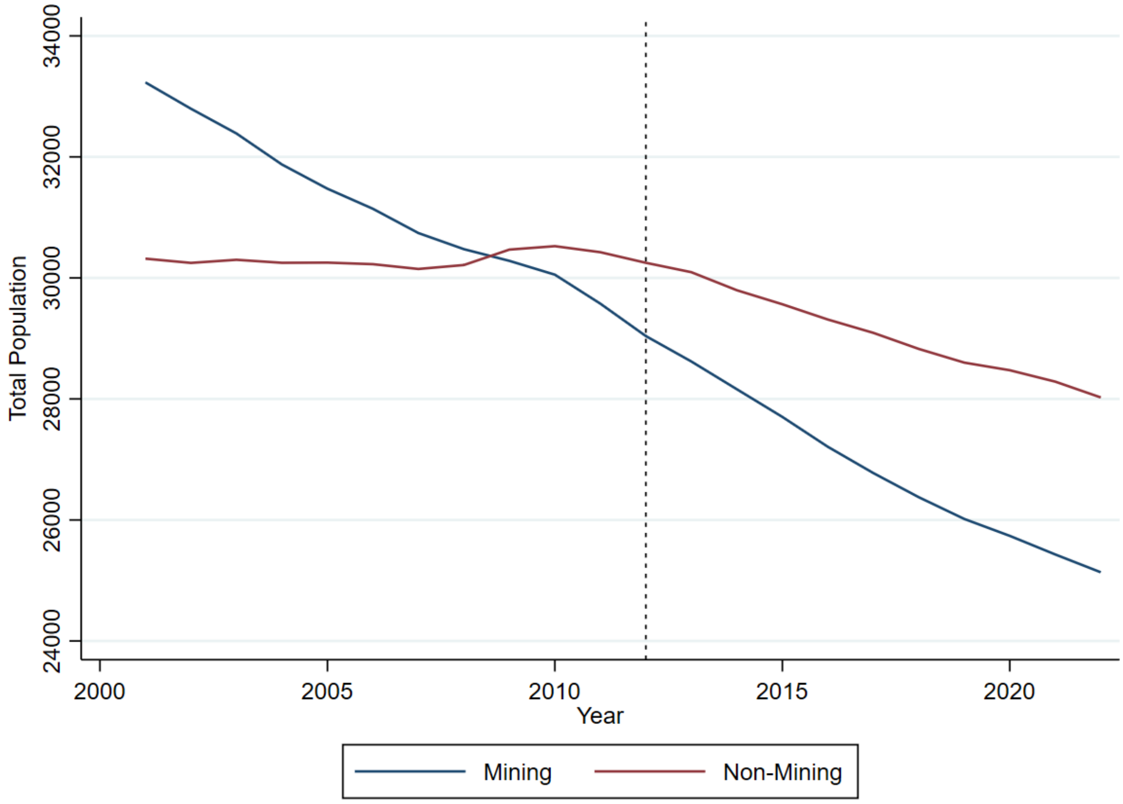
### 5.3. Applying synthetic controls

As a final way to account for the impact of the closure of the mines on those councils whose economy was highly dependent on the sector, I applied an approach based on synthetic controls. This would ultimately help to explain how the trends of both the demographic characteristics and the socioeconomic conditions of the population would have evolved if the mines had never closed.

To create a synthetic group of mining councils, the first step is to select a control and a treatment group. In this case, the selection was already made at the beginning of the analysis. The councils of Aller, Langreo, Mieres and San Martín del Rey Aurelio were chosen as Mining councils and assigned the role of the treatment group. Simultaneusly, Avilés, Carreño, Corvera and Gozón were chosen as the control group. The next step involves selecting the treatment period and identifying the intervention time. The treatment period encompasses the years for which socioeconomic data are available, specifically from 2001 to 2022. As for the intervention time, I have chosen 2012. This decision is based on the fact that 2012 marks the year with the highest number of mine closures in the councils that still had operational mine shafts after 2001, referred to as "Miners".

Figure XII illustrates the disparity in total population levels between the selected Mining and Non-Mining councils. This corresponds to the same depicted in Figure X, albeit with a longer timeline from 1900 in the former and a treatment period spanning 2001 to 2022 in the latter. The vertical line on the graph indicates the year 2012, which is regarded as the intervention period. In terms of the analysis' significance and the primary hypothesis that the closure of the mining sector in the treated councils had a detrimental impact on population levels, the current figure does not provide sufficient evidence to either support or reject it. Although the total population levels in the mining councils decrease after the intervention year, they also decrease in the Non-Mining councils, and both trends were observable from around 2010. Consequently, it becomes challenging to discern the true effect of mine closures in the selected councils solely by comparing them with the Non-Mining counterparts.

*Figure XII: Comparison of the Total Population trend between the selected Mining and Non-mining councils*




The synthetic control method helps identifying this effect. The main idea behind it is to combine the untreated units, the Non-Mining councils, so that they simulate the conditions of the treated unit, the Mining councils, as closely as possible and without the treatment. Lastly, this "synthetic unit" is used as a control. The following Table VII shows the weights given to each of the councils that are part of the donor pool. Table VIII includes descriptive statistics of the variables used in the construction of the "Synthetic Mining" and the weight given to them. As it can be seen, when compared to the Non-Mining councils, the values of the synthetic mining for each variable are closer to those of the actual mining councils, indicating that the synthetic control serves as a more precise comparison.

*Table VII: Weighting of each council in the construction of "Synthetic Mining"*

| Council | Weight |
|---|---|
| Avilés | 0.2600 |
| Carreño | 0.0000 |
| Corvera | 0.0050 |
| Gozón | 0.7350 |

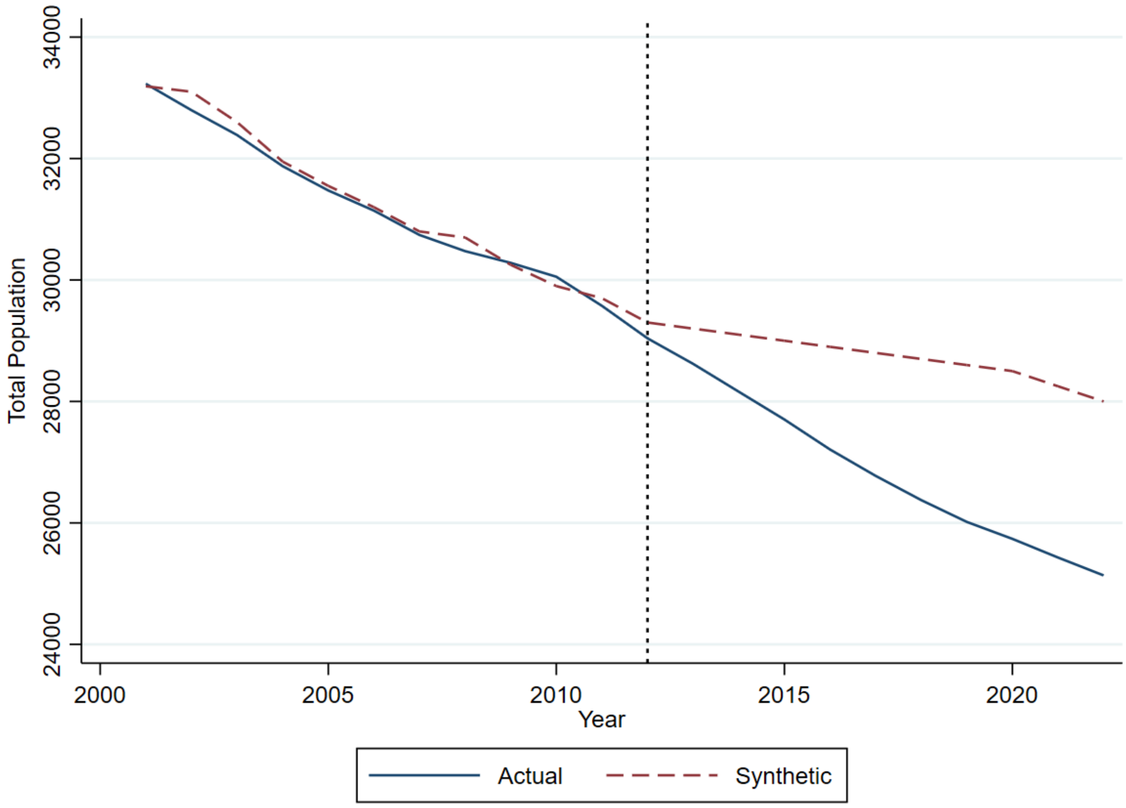
*Table VIII: Descriptive statistics and weighting of the variables used in the construction of "Synthetic Mining"*

| | Mining | Average Non-mining | Synthetic Mining | Weight |
|---|---|---|---|---|
| totalun | 12.5065 | 9.0671 | 10.163 | 0.0738 |
| GVApc | 1042.16 | 2240.4 | 1565.8 | 0.0420 |
| emigrants | 0.8078 | 0.9266 | 0.9183 | 0.0120 |
| immigrants | 0.8292 | 1.1200 | 1.1006 | 0.0021 |
| CBR | 5.0615 | 6.5396 | 6.0801 | 0.2138 |
| CDR | 14.2206 | 11.775 | 12.879 | 0.0750 |
| CMR | 3.1869 | 4.0249 | 3.9127 | 0.0688 |
| GMR | 5.8504 | 4.9446 | 5.0183 | 0.0100 |
| foreignrate | 2.1324 | 2.3858 | 2.2946 | 0.0772 |
| dependencyratio | 54.4722 | 53.3397 | 55.709 | 0.4254 |

*Notes: Columns 1-3 show the mean of the corresponding variables over the period 2001-2022. Columns 1 and 2 include simple averages of both the councils in the treatment and the donor group, respectively. Column 3 includes weighted averages using the weights produced by the synthetic control method. Column 4 lists the weight given to each variable.*

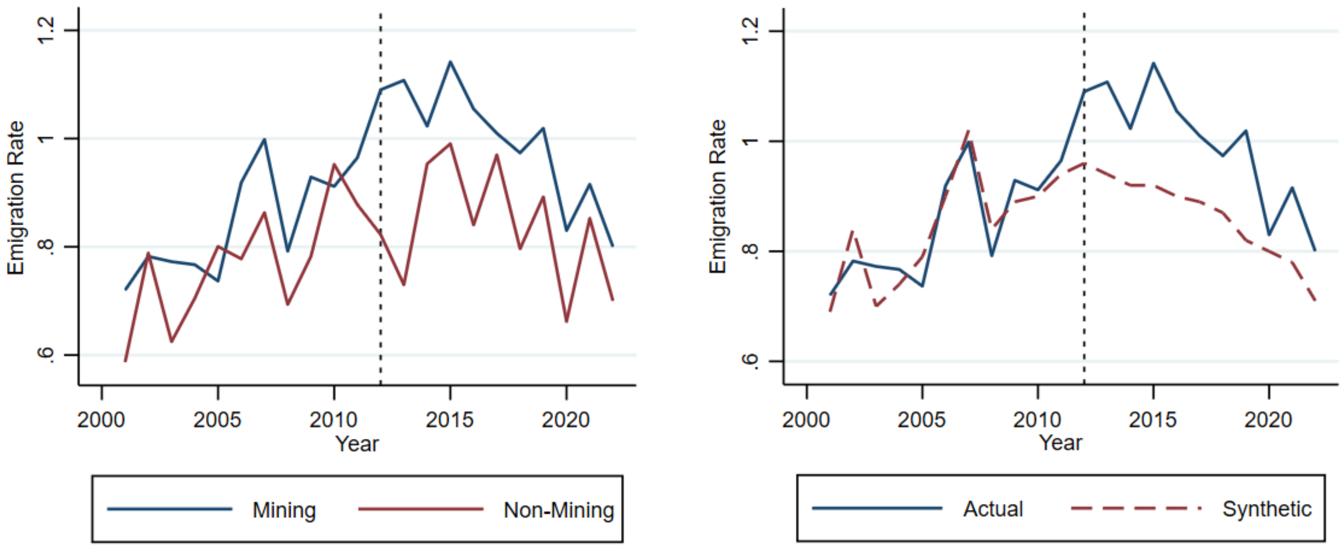
Following this, Figure XIII shows the trends of the actual group of selected Mining councils and the synthetic control, created from the characteristics of the non-mining councils. As it shows, both trends were more or less similar before 2012, the year of the intervention. However, from then on, both lines follow remarkably different trajectories. While the drop is quite pronounced in the group of Mining councils, it is not as sharp in the synthetic one, therefore more clearly showing the negative impact of the closure of the last open mine shafts. These results would support the initial hypothesis that the loss of population in those councils where the mining sector was of great importance to the economy was accentuated by its closure.

*Figure XIII: Comparison of the Total Population trend between the Mining councils and the synthetic Mining councils*



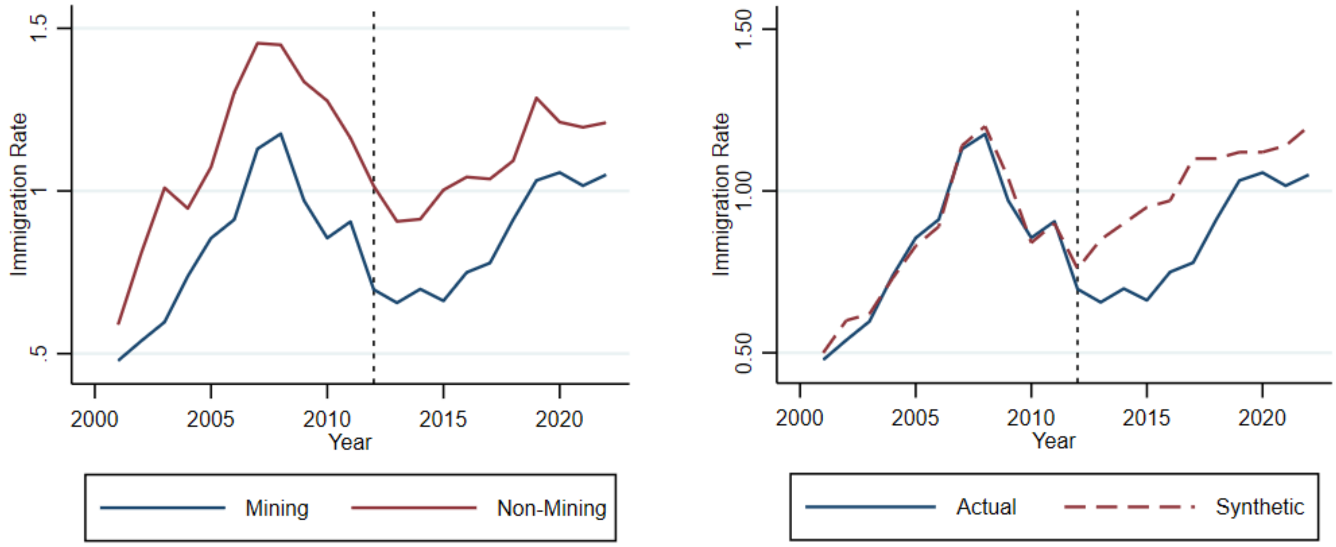

In order to add some robustness to the analysis, I repeated the synthetic control approach, this time with the previously identified variables: emigration, immigration, and Crude Birth Rates. First, following a similar scheme, Figure XIV shows, on the one hand, the average emigration rate trends in selected Mining and Non-Mining councils and, on the other hand, the actual and the synthetic mining emigration rate trends. As in the previous case, when considering total population levels, the emigration rate was higher in the selected Mining councils for most of the period. However, this became more evident in 2010. From then on, and even though emigration rates decreased in both groups, the one from the Mining councils stays higher compared to that of the Non-Mining ones. Nonetheless, as it happens when looking at the total population levels, the comparison of these trends does not show enough evidence to state that the closure of the last mine shafts had an impact on emigration in the affected councils. However, when looking at the trends of the actual Mining councils and the synthetic ones, the impact of the mine closures becomes more visible. From 2012 onwards, the synthetic trend is always lower than the actual one, showing that the closure of the last mine shafts operative in the Mining councils also impacted emigration rates, which would have been lower without the shock.

*Figure XIV: Comparison of the Emigration rate trend between the selected Mining and Non-mining councils and between the Mining and synthetic Mining councils*



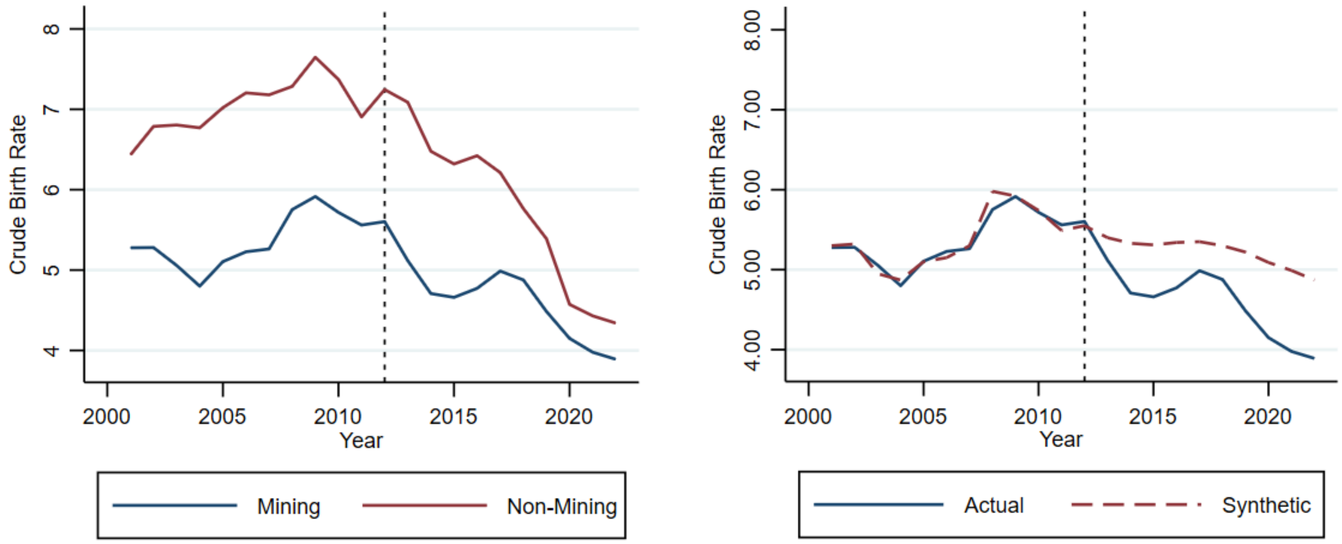

Regarding now the immigration rates, Figure XV shows the comparison of, first, the immigration rate trends of the Mining and Non-Mining councils and, second, the Mining and synthetic councils. In this case, immigration rates were always higher in the Non-Mining than in the Mining ones. However, as previously, this still does not speak about the effect of the mine shafts closures on the selected Mining councils. It is only when looking at the actual and synthetic trends that the effect of closing the mines becomes more evident again. Even though the actual trend increases from 2015 onwards, the synthetic one does so from 2012 on and to a greater extent, suggesting again a significative negative effect of the closure of the mines, this time on immigration rates. According to the results of the synthetic control, had the last mine shafts not been closed, the immigration rates would have remained higher, with the consequent effects in terms of population growth.

*Figure XV: Comparison of the Immigration rate trend between the selected Mining and Non-mining councils and between the Mining councils and the synthetic Mining councils*




Lastly, I also repeated the same steps with the Crude Birth date. The following Figure XVI compares the different trends followed by Mining and Non-Mining councils, and by Mining and synthetic councils. Like in the case of immigration, the Crude Birth Rate was higher in the Non-Mining councils for the entire period of analysis. However, this again does not prove enough evidence that the closure of the mining sector in the selected Mining councils had worsened this trend, since both groups had already declined since the early 2000s. Nevertheless, the comparison between the actual and synthetic trends confirms that the closure of the last mine shafts operative indeed affected the Crude Birth Rate of the selected Mining councils. Even though the trend followed by the Synthetic councils is still declining, it does not do so sharply, indicating that the shock provoked by the closure had a worsening effect on the Crude Birth Rate on the affected Mining councils.

*Figure XVI: Comparison of the Crude Birth Rate trend between the selected Mining and Non-mining councils and between the Mining councils and the synthetic Mining councils*




The synthetic control method is the last step of the empirical analysis. The following section aims to put together the different results obtained during the process. Lastly, it also offers some insight into the possible causes of the presented trends, as well as the reasons why the closure of the last mines in the region had such a significant impact on the affected councils although the sector had been in decline since the middle of the twentieth century.

## 6. Discussion

Between the beginning and the middle of the 20th century, the population of the selected Mining councils grew, in general terms, substantially more than that of the councils selected as Non-Mining and used as a comparison group. However, after that, and until the 1990s, population levels began to decline sharply among the Mining councils, while in the Non-Mining ones, the population continued to grow or was starting a slight decline. Between the 1990s and the present, the population decline is noticeable in both groups, however, among the Mining councils, it is even more pronounced than in the previous period. On the other hand, the Non-Mining councils, although also experiencing population loss, do not suffer such a sharp decline, and some even continue increasing their population.

In terms of total population, the levels were higher in the councils selected as Miners at the beginning of the 20th century. From then until the 1950s, they continued experiencing higher growth. In the case of the Non-Mining councils, although they also saw how their population increased, the growth was not as rapid. Between the 1950s and 1960s, both groups experienced significant increases in their total population levels. In the case of the Non-Mining councils, this trend remained stable until the 1970s, when the population continued to grow until the 1980s, although more contained, and then began to decrease to the current levels. However, in the case of the Mining councils, the trend began to fall in the 1960s, following a rapid and continuous decrease until today. Finally, this led to a situation where, at the end of the first decade of the 21st century, the total population levels of the selected Mining councils fell below those of the Non-Mining councils for the first time since the beginning of the 20th century.

However, the population density data offer a more accurate picture of the region's reality. This was higher among the Non-Mining councils at the beginning of the analysis, at the early twentieth century. However, around 1915, coinciding with the opening of most of the mining shafts in the region, the population started to grow in the Mining councils over the Non-Mining ones. The trend remained constant until 1950, when population density levels grew more strongly among the Non-Mining councils, eventually surpassing the Mining ones in the middle of the same decade. From 1960 onwards, coinciding with the beginning of the decline of the sector in Asturias, population density levels began to fall steadily in the Mining councils, following a downward trend that continues today. In contrast, population density continued to grow in the Non-Mining councils until the 1970s. From then on, the figures decreased among them as well, and have continued to fall until today. However, although population density continues to decline in both groups, the levels are much higher among the Non-Mining councils. On average, these have population densities of almost 900 inhabitants per square kilometer, while the figures are barely 300 inhabitants per square kilometer among the councils selected as Miners.

Different conclusions can be drawn regarding the econometric analysis of the first models presented above. First, the total unemployment rate, the Crude Marriage Rate, and the Value Added per capita, used as a proxy for the Gross Domestic Product per capita, significantly affect the emigration rate of the selected Mining Councils. According to the estimated coefficients, higher unemployment rates are correlated with higher levels of emigration, while the higher the Crude Marriage Rate or GVA per capita, the lower the emigration rates. Second, the total unemployment rate, the dependency ratio, the GVA per capita, and the Crude Marriage Rate significantly affect the Crude Birth Rate in the Mining councils. According to the estimated coefficients for each variable, high levels of unemployment or dependency are related to lower fertility rates, while the higher the GVA per capita or the Crude Marriage Rate, the higher the Crude Birth Rate. Third, the total unemployment rate, GVA per capita, and the population's average age are found to affect the immigration rate. As for the direction of these effects, higher levels of unemployment and average age disincentivize immigration, while the higher the GVA per capita, the higher the immigration rate. After this first part of the empirical analysis, it is possible to confirm the influence of the total unemployment rate and GVA per capita on the selected socioeconomic variables. Therefore, the relationship of both variables with the status of each council proves to be noteworthy.

Here, the estimations of the second group of models offer the first results in line with the hypothesis that the closure of the mines would have aggravated the already striking situation of population loss in the affected councils. In general, according to the coefficients obtained, it is possible to state that the relationship of each council with the mining sector would influence both their levels of total unemployment and GVA per capita. More specifically, having been a Mining council before the study period would be correlated with current higher levels of unemployment and lower GVA per capita, while being a Mining council during the study period would also be correlated with higher unemployment rates. In contrast, those councils in which mining never played a major role in their economies would have lower levels of unemployment and higher levels of GVA per capita today. Therefore, since both variables, total unemployment rate and GVA per capita, had previously been found to be significant when exploring the sociodemographic determinants of the Asturian population levels, it can be argued that these would be determined by whether or not a council has been exposed to mining at some point of its history.

Finally, the last part of the empirical analysis uses the synthetic controls method to observe the isolated effect of mine closures on the total population levels of the councils selected as Miners. The results provided by this method are in line with those obtained through the previous econometric analysis, and thus confirm the initial hypothesis. Total population levels decline throughout the period of analysis in the selected Mining councils, as they do in the synthetic council used as the unit of comparison. However, the drop in the latter from 2012 onwards, when most of the mine closures occurred, is significantly less pronounced. After analyzing the effect of mine closures on total population levels, the main object of the analysis, the synthetic controls method is also used with the emigration, immigration and Crude Birth Rate, the variables that had been previously selected as determinants of population levels. The results offered by the synthetic control method for these variables align with the previous ones. When observing the trends followed by the synthetic council, all of them maintain the direction of the current trend of the Mining councils; decreasing emigration and fertility rates and an increasing immigration rate. However, the values of all of them are significantly more positive for population growth in the Synthetic council than in the Mining ones; the fertility rate does not fall as sharply, while emigration decreases to a greater extent and the immigration rate increases significantly more pronounced.

## 7. Final Remarks

Consequently, I believe that the obtained results provide sufficient evidence to claim that, although the demographic situation of the mining councils was already in decline, in line with that of the rest of Asturias, the closure of the last mine shafts has significantly exacerbated the situation. The consequences of this effect are already noticeable in the most affected areas, which are at the forefront of depopulation in Asturias and Europe. However, as to the causes of this result, it seems reasonable to question why, although the inefficiency of the mining sector was well known since the mid-twentieth century and there were enough examples in Europe pointing to the inevitable decline of mining, it seems that this happened as a surprise to the affected areas. Despite the existence of numerous proposed alternatives, these never effectively materialized. On the one hand, attempts to convert the old mines into cultural patrimony through initiatives such as the European Coal Mining Museum Network, have not yet had the desired impact in Asturias, which is still far from being able to make any effective use of its infrastructures, most of which are abandoned or close to that point. On the other hand, the aid to former mining workers, known as "Mining Funds", which was initially intended for the productive restructuring of the region, has so far only served to support the following generation of families who had traditionally worked in the sector. The lack of employment alternatives in the affected areas has led young people to invest these funds in their education, however, the Mining Basins will not see the fruits of these efforts, since most of them will be driven to leave their councils, either to other parts of the region or the country. This connects with the theories about the rural exodus towards more urbanized areas within more developed countries. In the case of Asturias, a shock such as the closure of the industry that sustained some of the most productive areas of the region was the detonating factor that triggered its decline. The rapid increase in unemployment, especially among the youngest, accelerated emigration and discouraged immigration and birth rates, resulting in progressively fewer services being available in these areas, many of which are almost doomed to disappear. In this sense, it could be interesting trying to imitate the measures taken by other European regions that found themselves in a similar situation before, such as the Ruhr region in Germany, which has been able to reinvent its position successfully and is now one of the most populated areas in the country. Although Asturias has a relatively high population density given its surface area, its inhabitants are highly concentrated in the central areas. For this reason, and given the current housing crisis in big cities, I believe that areas such as the Asturian Mining

Basins have a unique opportunity since the beginning of its decline to reinvent themselves and offer an attractive alternative to the massification of the big cities.

## 8.References

ABADIE, A., & GARDEAZABAL, J. (2003). “The economic costs of conflict: A case study of the Basque Country”. American economic review, 93(1), 113-132.

ABADIE, A., & L’HOUR, J. (2021). “A penalized synthetic control estimator for disaggregated data”. Journal of the American Statistical Association, 116(536), 1817-1834.

ABADIE, A., DIAMOND, A., & HAINMUELLER, J. (2010). “Synthetic control methods for comparative case studies: Estimating the effect of California’s tobacco control program”. Journal of the American statistical Association, 105(490), 493-505.

ACS, Z. J., AUDRETSCH, D. B., BRAUNERHJELM, P., & CARLSSON, B. (2012). “Growth and entrepreneurship”. Small Business Economics, 39, 289-300.

ADSERA, A. (2005). “Vanishing children: From high unemployment to low fertility in developed countries”. American Economic Review, 95(2), 189-193.

ALMEIDA, M. (2018). “Fighting depopulation in Portugal: Local and central government policies in times of crisis”. Portuguese Journal of Social Science, 17(3), 289-309.

ÁLVAREZ QUINTANA, C. (1986). “Casa y carbón. La vivienda minera en la Cuenca del Caudal, 1880-1936”. Libro nº6, pp.83-89.

ANDERSEN, S. H., & ÖZCAN, B. (2021). “The effects of unemployment on fertility”. Advances in Life Course Research, 49, 100401.

Balasch, J. & Gratacós, E. (2011). “Delayed Childbearing: Effects on Fertility and the Outcome of Pregnancy”. Fetal Diagn Ther; 29 (4): 263–273.

BANCO DE ESPAÑA. (2022). “Informe Anual”.

BARRO, R. T., & SALA-I-MARTIN, X. (1992). “Regional growth and migration: A Japan-United States comparison”. Journal of the japanese and International Economies, 6(4), 312-346.

BECKER, G. S. (1992). “Fertility and the economy”. Journal of Population Economics, 5(3), 185-201.

BILSBORROW, R. E. (1992). “Population growth, internal migration, and environmental degradation in rural areas of developing countries”. European Journal of Population/Revue européenne de Démographie, 125-148.

BONGAARTS, J. (2009). “Human population growth and the demographic transition”. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1532), 2985-2990.

BONGAARTS, J. (2015, January). “Global fertility and population trends”. In Seminars in reproductive medicine (Vol. 33, No. 01, pp. 005-010). Thieme Medical Publishers.

BONO, E. D., WEBER, A., & WINTER-EBMER, R. (2015). “Fertility and economic instability: The role of unemployment and job displacement”. Journal of Population Economics, 28, 463-478.

COALE, A. J., & HOOVER, E. M. (2015). “Population growth and economic development (Vol. 2319)”. Princeton University Press.

CRAIG, J. (1994). “Replacement level fertility and future population growth”. POPULATION TRENDS-LONDON-, 20-20.

CURRIE, J. & SCHWANDT, H. (2014). “Short-and long-term effects of unemployment on fertility”. Proceedings of the National Academy of Sciences, 111(41), 14734-14739.

ESHRE Capri Workshop Group. (2005). “Fertility and ageing”. Human Reproduction Update. Volume 11, Issue 3, Pages 261–276.

FERMAN, B., & PINTO, C. (2021). “Synthetic controls with imperfect pretreatment fit”. Quantitative Economics, 12(4), 1197-1221.

FERNANDEZ LORENZO, G. (1989). “Apuntes para una historia de la minería asturiana”. Mieres, 1989.

FERNANDEZ-CREHUET, J. M., GIL-ALANA, L. A., & BARCO, C. M. (2020). “Unemployment and fertility: A long run relationship”. Social Indicators Research, 152, 1177-1196.

GARCÍA BLANCO, J. M. & GUTIERREZ, R. (1988). “El declive industrial en las Cuencas Mineras Asturianas”. Abaco, nº4. Oviedo.

GLOMM, G. (1992). “A model of growth and migration”. Canadian Journal of Economics, 901-922.

HAHN, J., & SHI, R. (2017). “Synthetic control and inference”. Econometrics, 5(4), 52.

HERR, J. L. (2016). “Measuring the effect of the timing of first birth on wages”. Journal of Population Economics, 29, 39-72.

HOPENHAYN, H., NEIRA, J., & SINGHANIA, R. (2022). “From population growth to firm demographics: Implications for concentration, entrepreneurship and the labor share”. Econometrica, 90(4), 1879-1914.

HUNOSA. (2018). “Archivo Histórico”.

Instituto Nacional de Estadística. (2021). “Censos de Población y Viviendas”.

INSTITUTO NACIONAL DE ESTADÍSTICA. (2021). “Informe Anual”.

Instituto Nacional de Estadística. (2022). “Cifras de población. Datos definitivos”.

JOHNSON, K. M. (2003). “Unpredictable directions of rural population growth and migration”. Challenges for rural America in the twenty-first century, 19-31.

KAUL, A., KLÖßNER, S., PFEIFER, G., & SCHIELER, M. (2022). “Standard synthetic control methods: The case of using all preintervention outcomes together with covariates”. Journal of Business & Economic Statistics, 40(3), 1362-1376.

KIBIRIGE, J. S. (1997). “Population growth, poverty and health”. Social Science & Medicine, 45(2), 247-259.

KISS, M. (2022). “Demographic Outlook for the European Union”. European Parliamentary Research Service.

LAM, D. (1986). “The dynamics of population growth, differential fertility, and inequality”. The American Economic Review, 1103-1116.

LI, K. T. (2020). “Statistical inference for average treatment effects estimated by synthetic control methods”. Journal of the American Statistical Association, 115(532), 2068-2083.

MASINI, R., & MEDEIROS, M. C. (2022). “Counterfactual analysis and inference with nonstationary data”. Journal of Business & Economic Statistics, 40(1), 227-239.

MINISTERIO DE INCLUSIÓN, SEGURIDAD SOCIAL Y MIGRACIONES. (2023). “Informe Económico Financiero”.

PAŠIĆ, M., IVKOV-DŽIGURSKI, A., & DRAGIN, A. (2010). "Unemployment as one of the leading problems of depopulation in border municipalities of Banat". Zbornik Matice srpske za drustvene nauke, (131), 279-292.

PATRIMONIU INDUSTRIAL. (2019). "Archivo Histórico".

PÉREZ GONZÁLEZ, R. (1993). "El espacio industrial de las cuencas hulleras". Geografía de Asturias, 5, pp. 6-15. Ayalga. Salinas, 1983.

PINILLA, V. & SÁEZ, L. A. (2017). "La despoblación rural en España: génesis de un problema y políticas innovadoras". Informes CEDDAR, 2, 1-24.

SANTULLANO, G. (1998). "Historia de la minería asturiana". Ayalga Ediciones.

SECRETARÍA GENERAL PARA EL RETO DEMOGRÁFICO. (2022). "El reto demográfico y la despoblación en España en cifras". Vicepresidencia cuarta y Ministerio para la Transición Ecológica y el Reto Demográfica. Gobierno de España.

SIMON, J. L. (2019). "The economics of population growth". Princeton university press.

SOBOTKA, T., SKIRBEKK, V., & PHILIPOV, D. (2011). "Economic recession and fertility in the developed world". Population and development review, 37(2), 267-306.

SOCIEDAD ASTURIANA DE ESTUDIOS ECONÓMICOS INDUSTRIALES. (2014). "Información Estadística".

SUÁREZ ANTUÑA. "La organización de los espacios mineros de la hulla en Asturias". Revista electrónica de Geografía y Ciencias Sociales. Universidad de Barcelona. ISSN: 1138-9788. Depósito Legal: B. 21.741-98
Vol. IX, núm. 203.

WEEDEN, J., ABRAMS, M.J., GREEN, M.C. (2006). "Do high-status people really have fewer children?". Hum Nat 17, 377–392.