Does anyone live here? Mine closures and depopulation in Spanish coal mining areas

¿Vive alguien aquí? Cierre de minas y despoblación en las zonas mineras de España

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Abstract

One of the most pressing socio-economic issues across EU countries has been the depopulation of a significant part of its territory. Less urbanized areas are perceived as non-attractive places to live and have been losing population steadily in the latest decades. For the case of Spain, this European-wise phenomenon has been exacerbated for several territories characterized by a large presence of primary and extractive industries in the past. We quantify empirically the contribution that the closure of the heavily subsidized coal mining had on the depopulation trends experienced in mining-intensive areas in Spain. This poses an interesting research question, since both non-mining and mining territories in Spain suffered a remarkable negative down trend in demographic terms since early nineties, which was the period on which the coal mining industry started to cease steadily its activity. Our empirical strategy relies on matching estimators that compare the demographic trend across mining-intensive and non-mining intensive municipalities in four provinces, controlling for observable characteristics and isolating the net effect of the "shock" originated by the termination of this mining activities. Our analysis finds a statistically significant and sizable negative effect on the fall of population for mining-intensive municipalities between 1991 and 2011.

Keywords: coal mining, matching estimators, local resource curse, population decline.

Resumen

Uno de los problemas socioeconómicos más urgentes en los países de la UE ha sido la despoblación de una parte significativa de su territorio. Las áreas menos urbanizadas se perciben como lugares poco atractivos para vivir y han estado perdiendo población de manera constante en las últimas décadas. En el caso de España, este fenómeno europeo se ha visto exacerbado en varios territorios caracterizados por una gran presencia histórica de industrias primarias y extractivas. Cuantificamos empíricamente la contribución que tuvo el cierre de la minería del carbón, fuertemente subvencionada, en las tendencias de despoblación experimentadas en las áreas intensivas en minería en España. Esto plantea una cuestión de investigación interesante, ya que tanto los territorios mineros como los no mineros en España han sufrido una notable tendencia negativa en términos demográficos desde principios de los años noventa, período en el cual la industria minera del carbón comenzó a cesar progresivamente su actividad. Nuestra estrategia empírica se basa en estimadores de emparejamiento que comparan la tendencia demográfica entre municipios con alta y baja intensidad minera en cuatro provincias, controlando por características observables y aislando el efecto neto del "shock" originado por el fin de estas actividades mineras. Nuestro análisis encuentra un efecto negativo, estadísticamente significativo y considerable, en la caída de la población de los municipios mineros entre 1991 y 2011.

Palabras clave: *minería del carbón, estimadores de emparejamiento, maldición de los recursos locales, maldición de los recursos locales.*

Summary

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1. Introduction

The depopulation of a substantial portion of the European Union's territory has emerged as one of the most urgent socio-economic challenges in recent years. Regions experiencing population decline confront the challenge of diminishing local tax revenues, which has a direct impact on the provision of essential services (Carbonaro *et al*., 2018; Franklin *et al*., 2018). These transformations give rise to their own social and economic ramifications, including income inequalities (Butler *et al*., 2020; San Juan & Sunyer, 2020) and a decline in regional competitiveness (Poot, 2008; Kotenko *et al.,* 2021). The decline can also impact the way local areas are self-perceive, making more difficult to envision alternative futures (Perez-Sindin & Van Assche, 2020). This European-wise phenomenon has been exacerbated for several territories characterized by a relatively large presence of primary and extractive industries in the past. This paper focuses on the traditionally coal mining-intensity areas in Spain. We try to quantify empirically the contribution that the closure of the heavily subsidized coal mining had on the depopulation trends compared to non-mining rural areas. The results of this study, we argue, hold potential for better understanding the causes of rural population decline and can have broader policy implications.

A substantial amount of work has been done to understand population decline as a contemporary phenomenon (Newsham & Rowe, 2023) As reported by Eurostat Statistics, the incidence of depopulation is higher in rural areas, particularly those far away from the main urban centers (this has been probed, at least, for Poland (Wojewodzka-Wiewiorska, 2019), Latvia (Pužulis & Kūle, 2016) and Lithuania (Ubarevičienė *et al*., 2016). Population size seems to be another important factor of depopulation. As probed by Kabisch and Haase (2011), smaller-sized cities agglomerations were more likely to experience population decline than large and mid-sized agglomerations. In contrast, Newsham and Rowe (2023) revealed that small-and mid-sized areas exhibited diverse depopulation trajectories, underscoring the significance of local contextual factors in shaping the patterns of population decline. As argued by Newsham and Rowe (2023), the study of contemporary population decline is frequently depicted in a manner that highlights the contrasting trajectory of population change between rural and urban areas (see for example, (Franklin, 2020) and between different urban areas (Haase *et al*., 2016) This leaves numerous essential questions unanswered: what are the causes of population decline in the most affected areas, i.e., rural areas? Does the population decline differ dependent on the main economic sector of those areas? By focusing on the depopulation trends in Spanish mining areas compared to non-mining areas, this article contributes to answer these questions.

The case of Spain can indeed be particularly instructive for studying the broader issue of depopulation. The country had a very rapid economic growth in the last four decades, presenting a very strong, concentrated process of urbanization (Lamela *et al*., 2014; Navamuel *et al*., 2018). Cities such as Madrid and Barcelona doubled their populations in less than twenty years. Spain's rural regions, on the other hand, have lost 28 percent of their population and are now popularly known as *España vacia*, or "empty Spain" (Ayala García & Abellán García, 2018). This process coincided with the period on which the coal mining industry started to cease steadily its activity, affecting primarily traditional mining areas. Against this background, our study aims to compare the depopulation decline in these two types of rural areas. Moreover, it is important to consider that some of the main rural revitalization policies carried out in Spain since the 1990s had the primary objective of addressing the decline in mining areas following mine closures. Programs such as the so-called "Plan Miner" were implemented at the time to tackle this issue. This prompts an intriguing inquiry: to what extent have these policies succeeded in mitigating population decline in mining areas? Is the decline in mining areas indicative of the broader decline experienced by rural areas in Spain, suggesting relative success in revitalization efforts? Alternatively, has the decline in mining areas been more pronounced, casting doubt on the efficacy of these revitalization policies? Further exploration of these questions is warranted in this article.

The results of this study can help to design coal phase out policies in a context of energy transition and climate change adaptation. Research on the implications of phase out coal has expanded rapidly in recent years (Kalkuhl *et al*., 2019; Rentier *et al*., 2019) However, most studies have primarily focused on the historically prominent coal producers in Europe, notably Germany and the United Kingdom. Therefore, reading the case of Spain, the history of the coal industry, policies, and the implications in terms of demography for the most affected regions we offer a complement to current energy transition research. The article also relates to recent debates regarding local natural resources curse (Allcott and Keniston, 2018; Brollo *et al*., 2013; Esposito & Abramson, 2021; Gradstein & Klemp, 2020). Most of these studies explore whether the abundance of natural resources have either a positive or negative effect in the local economies, with mixed results. By looking at the demographic changes, this article offers a complement to this emerging literature, primarily focused on economic indicators such as GDP.

The structure of the paper is as follows. In section two, a comprehensive account is provided of the history of coal mining in Spain, including political circumstances surrounding the industry's emergence since the 19th century, the significant growth experienced throughout the 20th century, the geographical distribution of coal production, and the subsequent implementation of revitalization policies since the onset of its decline, particularly from 1990 onwards. Section three presents the methodology, outlining the overall empirical strategy, the database used, and offering a brief description of the areas that will be studied. Moving on to section four, the results of the analysis are presented. Finally, section five concludes the paper by summarizing the main findings and providing some closing remarks.

2. Context: History and geography of coal in Spain

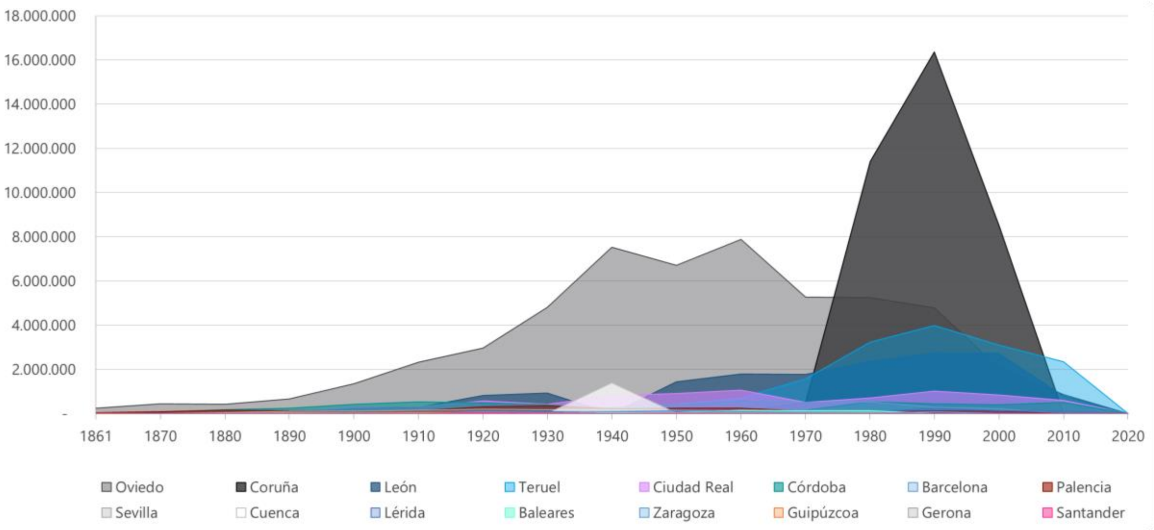
Although Spain had significant coal reserves, the quality was not high, and extraction and transportation costs were high (Sudríá, 1992; Sudrià, 2001). The deposits were discontinuous, narrow, and inclined, making mechanization and extraction challenging. Additionally, the mountainous locations of the mines made transport and commercialization more expensive. As a result, Spanish coal was more costly than imported coal, with foreign coal comprising over 80% of coal imports into Spanish ports before World War I (Rodríguez-Martín, 2021). Coal extraction played, however, a significant role in development of certain regions in Spain, particularly in regions like Asturias, which was the largest producer throughout the 19th and 20th centuries (Nadal, 1975). Other regions where coal extraction began during the second half of XIX century and expand during the two first decades of XX were Córdoba, Sevilla in the south (an average share of 12% and 5% between 1861 and 1930, respectively), Ciudad Real, 200 km north Córdoba (11% in 1900), Palencia, in Castilla, north center Spain (14% average between 1861 and 1890), as well as in the Spanish most industrialized regions of Catalonia and Basque Country: Barcelona, Girona, Lerida (northeast) and Guipúzcoa (North), representing each of them not less than 2% average between 1860 and 1900.

During the late 19th and early 20th centuries, Spain experienced conflicts between supporters of free trade and protectionism, which influenced its mining industry. Protectionism prevailed, and measures were taken to promote nationalization and favor Spanish companies and engineers (Díaz Morlán & Escudero, 2012). Production in Asturias, for instance, tripled between 1920 and 1940. During this period, another region with long coal mining tradition in Spain, León (gray stripe in Graph 1), emerge as the second most important center of coal production, including hard and anthracite. In 1920 alone, the region produced approximately 13% of the national coal (Vega Crespo, 1994) for a more detailed description of coal industry in León). At that time, both regions, Asturias and Leon, accounted for over 60% of Spanish coal production.

After the Spanish Civil War (1936-1939), Spain adopted an autarkic development model and created the Instituto Nacional de Industria (INI) to promote domestic production. The national coal industry played a crucial role in the post-war industrialization process [see Sánchez Melado (2007) on the protectionism of coal in León]. Endesa, a company under the INI, built one of the first thermal power plants in León, during this period. However, the late 1950s marked the end of the national coal boom, as external competitiveness, the return of foreign coal, and the emergence of oil as a primary energy source posed challenges to the industry. Despite the government's nationalization efforts, production and employment in the coal industry declined significantly between 1959 and 1977 (Graph 1).

In the 1970s and 1980s, the coal industry in Spain underwent significant changes driven by the oil crisis and technological advancements. Following the trend in other Western countries, the Spanish government promoted the development of large-scale open-cast coal mines. New open-cast mines were also established in regions with less mining tradition. The main concentration of production occurred in As Pontes and Cerceda, both in A Coruña province, Galicia, with As Pontes becoming a major production center. In 1982 alone, As Pontes produced 14 million tons of brown coal, accounting for 50% of Spain's total coal production that year (see also orange stripe in Graph 1). Another of the regions that will acquire some relevance in terms of production from the 1970s is Teruel, with an average of 14% of the national production between 1970 and 1990.

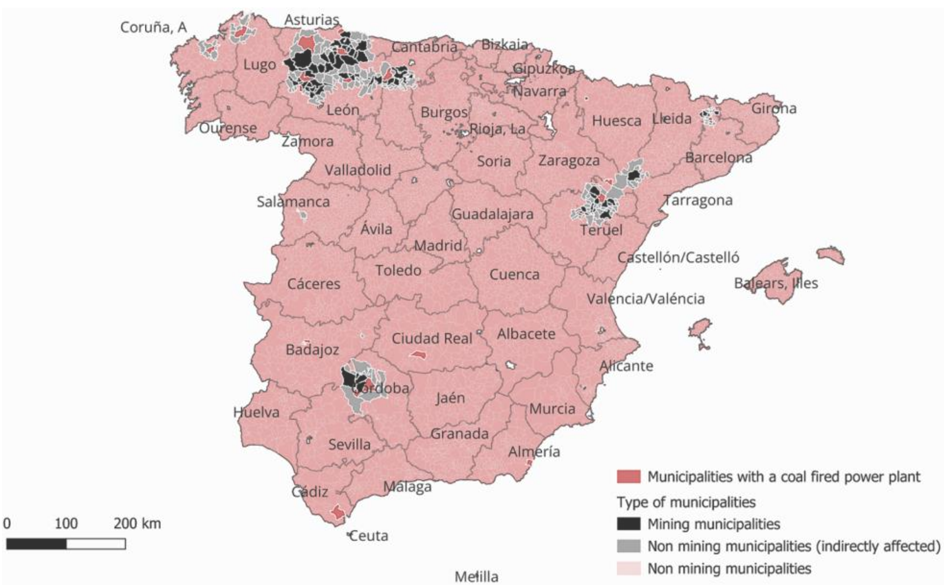
Graph 1. Production of anthracite, coal, and Lignite in Spain, 1861-2020



Source. Own elaboration based on data from *Estadísticas Mineras*, Spanish Ministry Ecological Transition.

This new spatial restructuring of the sector will be essential to understand the dynamics of the sector going forward. Underground mines were concentrated in Asturias, León and in a lesser extent Teruel, representing traditional mining regions. The opencast coal boom posed a threat to these regions, as they couldn't compete in terms of extraction costs. Between 1984 and 1999, the number of mining companies in Spain drastically declined from 236 to 66 (del Rosal Fernández, 2004), particularly in the hard coal and anthracite sector (from 174 to 55). The concentration of production increased in new coal geographies, particularly in lignite opencast mines. In the case of As Pontes, A Coruña, where 50% of national production took place, a single public company, Endesa, owned both coal and electricity production.

Figure 1. Map of coal mining municipalities in Spain



Source. Own elaboration based on a list of municipalities benefiting from aid for the restructuring of mining areas, Ministry for Ecological Transition and Demographic Challenge, (Government of Spain, 2007).

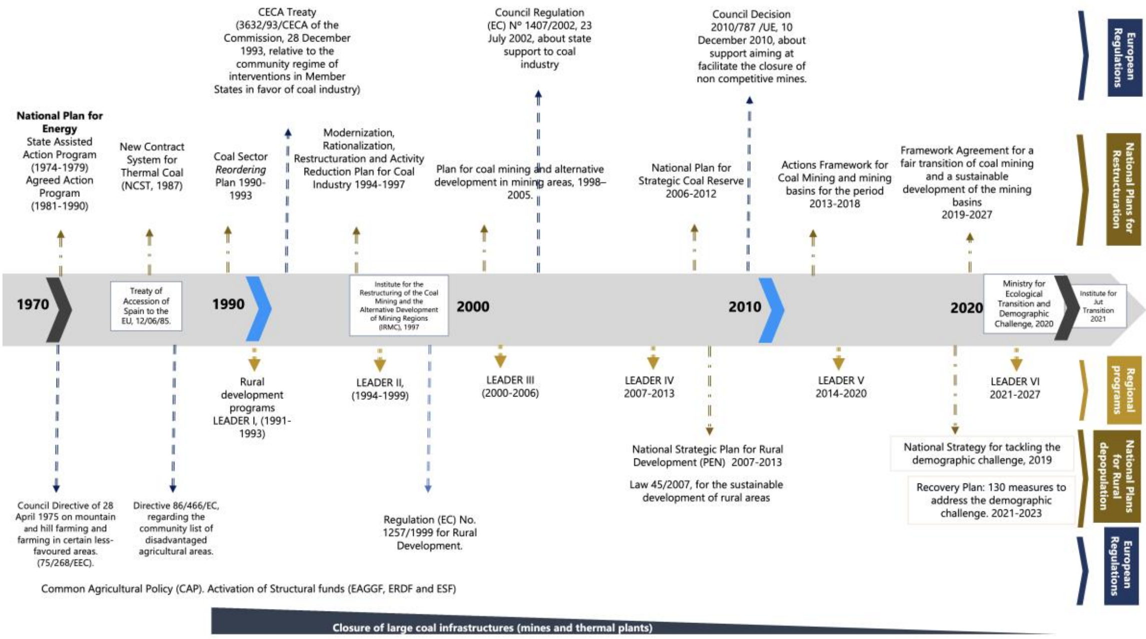
Spain's entry into the European Union in 1986 eliminated the ability to regulate prices. The protectionism toward national coal persisted, however, in the following years. The coal producers' association (CARBUNION) and electricity producers (UNESA) signed the so-called Thermal Coal Contracting System in 1987. This contract liberalized prices for opencast mines yet set a reference price for underground mines (See Fernández, 2000 for more details on protectionism and coal policy during this period).

The introduction of CO2 regulations by the European Union, such as Directive 93/76/EEC (1993) and Directive 2003/87/EC (2003), led to a significant decrease in the extraction of brown lignite from the mid-1990s. The share of coal in the electricity mix remained relatively high until 2008 due to imported coal, but gradually decreased due to the implementation of Directive 2010/75/UE on industrial emissions and the growing use of gas. Gas-fired power plants saw significant growth, with 30 new facilities built since 2000. The As Pontes power plant, the largest in Spain, was transformed to burn imported coal from Indonesia and Colombia alongside gas. However, these changes were temporary, as Spain ceased coal production in 2018, and most power plants stopped operating before that year. The increasing cost of CO2 emissions and the implementation of environmental regulations led to the closure of the remaining coal-fired power plants.

2.1. Post-mining regional development strategy and policies

Starting from the year 1990, Spain implemented several subsequent plans to address the specific problems associated to the decline of coal production – popularly known as "Plan Miner" (see the schedule of the different plans in Figure 2).

Figure 2. Timeline of Public Policies on Carbon and Rural Development in Spain



Source. Prepared by the authors.

Unlike the previous plans, which had a predominantly protectionist approach towards the mining industry, these new plans aimed at reducing production, gradually eliminating compensatory measures for the coal sector, and establishing a plan to ensure the sector's competitiveness. Measures aimed at diversifying local economies will increasingly gain importance within the plans from 1994 onwards.

The plan for the period 1994-1999, for instance, allocated €7.2 billion in aid for the coal regions, with a significant portion dedicated to labor costs, early retirement schemes, and financial support for industrial restructuring and investment initiatives (see González Rabanal, 2005, for more details) In 1997, the government created the Institute for the Restructuring of Coal Mining and Alternative Development of Mining Regions (IRMC), aimed at coordinating funds, and promote economic diversification. The policies remained largely unchanged in their essence, with a greater emphasis on the creation of industrial land and investment incentives (tax break policy to attract investors to the newly created industrial parks).

By late 2011, Spanish coal regions had received €1,542 billion for regional development projects (UGT and CCOO, 2015)(compared for instance with 2,135 billion national public spending in generic rural development programs such as EU LEADER for the period 1991-2013 (see Reinoso Moreno D. and Sancho Comíns J., 2011) This included €933 million for infrastructure, €361 million for entrepreneurial projects, and €248 million for training. It is important to note that mining areas in Spain also benefited from rural development programs designed for rural and declining industrial areas (LEADER is a good example) This means that, for at least 15 years, mining areas became one of the most attractive regions for launching new entrepreneurial projects. Indeed, coinciding with the years prior to the financial crisis –land liberalization and significant urban growth in Spain –many new industrial parks were then created in the Spanish coal regions. Figures to 2006 (the latest year reported by IRMC) show that 227.9 million euros was spent on building industrial parks. The investment in infrastructure also included project of different nature: roads, construction of museums, senior residence, and other collective equipment.

During the years of the economic crisis, the Miner Plan in Spain continued along the same path, albeit with significantly reduced budget allocations. Since the closure of the last mines in 2018, The Spanish government has allocated funds and resources for the implementation of the so-called energy transition contracts. Compared to Miner Plan, the new contracts establish specific commitments and measures to promote economic reactivation through renewable energy projects (see Sanz-Hernández *et al.*, 2020).

3. Methodology: quantifying the effect of mine closures by matching techniques

The section consists of, first, a definition of the criteria used to distinguish between mining and non-mining municipalities, then the main data sources and the empirical strategy.

3.1 Selecting mining municipalities

The selection of mining areas follows several criteria. Firstly, we consulted the Ministry to obtain a list of municipalities considered as mining municipalities for the purposes of industrial restructuring policies implemented since the 1990s (Spanish Government, 2007). It is important to note that closure of coal mines is the only criteria used by the Ministry to make municipalities eligible to be considered mining areas. This results in the list of municipalities having significant variations in terms of municipality size. For instance, the list includes both municipalities with barely 200 inhabitants, such as *Cañizar de Olivar* in Teruel, to provincial capitals like Oviedo, with over 225,000 inhabitants. However, this does not necessarily mean that their economy has revolved around the mines or that these policies have had a notable impact on their overall economy. For this reason, our analysis is exclusively limited to medium-sized and small municipalities where mining has played a central role in the local economy.

The list of the Ministry presents also important variations in terms of geographical location. 64% of the total 84 municipalities are concentrated in three neighboring provinces in the northwest of Spain: León, Asturias, and Palencia. Another important concentration occurs in Teruel –eastern part of Spain (18%), while the remaining 18% are distributed across seven different provinces scattered throughout Spain. Following a geographical criterion, our analysis focuses on the abovementioned provinces, which in turn, are characterized for being the most traditional mining regions (and mostly underground mines). This means that some of the "new coal geographies" have been excluded from the analysis, i.e., areas where the development of large-scale open cast coal mines –including the construction of power plants– was prominent in the 1970s. This is the case of, for instance, As Pontes, in A Coruña, one of the top producers in the last three decades. These are locations that get close to the concept of an "energy boomtown" (Pérez-Sindín, 2021), i.e., rural areas where a sudden mining boom provokes the sudden influx of young males earning high salaries and having few if any roots in these communities, conflicts between long-term residents and newcomers and incapacity to accommodate waves of rapid population growth. The socioeconomic differences compared to traditional mining areas make them deserve a separate analysis. For the purposes of this study, we have decided to exclude them.

3.3 Data collection and sources

We have collected information form Population Censuses for the time span that goes between 1970 to 2021. After some data cleaning (e.g., eliminating municipalities with missing information and with population smaller than 100 inhabitants), we end up with a sample size of $n = 228$ observations, of which 88 corresponds to municipalities classified as coal mining-intensive by the Ministry. For our analysis, we only consider municipalities in the provinces of Asturias, Leon, Palencia and Teruel. We were just interested in comparing local mining areas experiencing common contextual characteristics (i.e., at province level) with other non-mining areas. Therefore, the comparisons are always made with municipalities in the same province, which led us to exclude provinces on which the number of mining municipalities were too low. Table 1 shows summary statistics of municipal characteristics distinguishing between both classes of areas.

Table 1. Descriptive statistics of municipal characteristics

Mean values	*Mining*	*Non mining*
Population changes 2011-2021 (%)	-1.276	-0.388
Population changes 1991-2011 (%)	-0.867	1.292
Population changes 1970-1991 (%)	-0.731	0.047
Population 2021 (logs)	8.210	7.602
Population 2011 (logs)	8.349	7.650
Population 1991 (logs)	8.553	7.537
Population 1981 (logs)	8.632	7.557
Population 1970 (logs)	8.745	7.637
Population 1960 (logs)	8.881	7.740
n	42	186

Note: population levels are expressed as the logs on the number of inhabitants. Population growth rates are expressed as mean annual rates in percentage. / Source. Prepared by the authors using data from the Population and Housing Census of the National Institute of Statistics.

The values reported in Table 1 show that mining-intensive areas had different characteristics if compared with the non-mining counterparts. Our main interest was to study if there was a significant difference in the demographic trend between mining and no-mining areas during the decades after implementing the policies that cut off the public subsidies to coal mining. Paying attention to the change of population between 1991 and 2011, they had experienced on average a much larger negative trend: a drop of approximately 17% throughout those twenty years, compared with more than 25% increase in non-mining areas). In the following decade, between 2011 and 2021, this negative trend kept getting worse, losing more than 12% of population while non-mining areas in the same provinces were losing on average less than 4% in the same period. These figures suggest that mining municipalities had suffered a more severe depopulation process since 1991 than those classified as non-mining. But part of that difference could be attributed to other local characteristics apart from the fact of being affected by the mine closures.

The empirical strategy followed to identify the effect of the mine closure that happened in the early nineties in the demographic trends observed in the following twenty years is, roughly speaking, based on comparing mining and non-mining with "identical" observable characteristics. More technically, we rely on a nonexperimental evaluation method family of techniques known as matching estimators, and more specifically we will apply a Nearest Neighbor Matching (NNM) technique, which in recent years has become one of the preferred methods for estimating intervention impacts using comparison group data and has gradually replaced more traditional strategies as estimating regression equations. NNM estimators are variant of the matching techniques that aim at matching observations belonging to each one of the comparison groups, provided that they have similar observables. More specifically, NNM use information from a pool of units that do not present the characteristic of interest –i.e., non-mining– to identify what would have happened to the units that do present that characteristic –i.e., mining-intensive– in the absence of it (Abadie & Imbens, 2006; Cattaneo, 2010; Abadie & Cattaneo, 2018). The aim of the NNM estimator is to be as close as possible to a case on which randomized trials are the basis for evaluating the effect of certain treatment: when experimental designs are not possible, the assignment to treatment is usually nonrandom, since the units that receive it and those that do not receive it may differ also in other characteristics that affect both participation and the outcome of interest. Matching methods try to avoid the bias that this could generate by finding a nontreated unit as similar as possible to a participating unit, estimating the effect of interest as the difference in outcome between both units. Averaging across all the sampled units, these procedures produce estimates of the mean effect (see Annex 2 for details).

The basis for quantifying these similarities is the list of covariates reported in Table 1: the initial population size in the initial year and lagged ten years, being all the variables expressed in natural logarithms. Additionally, to control time-invariant spatial characteristics, the surface (in square kilometers) and the geographical location (West and North coordinates) have been considered as well. For example, the estimate of the ATT for the period 1991-2011 will consider as covariates for the marching the populations in 1981 and 1991, together with the surface and the geographical coordinates.

4. Results

4.1. The effect of mine closures on depopulation: 1991-2011 and 2011-2021

The diagnosis presented in the previous section suggests that the main assumptions required to apply the NNM estimator hold in the sample studied with the specification of covariates considered. The estimates of the mean effect of mine closures on the population change between 1991 and 2011 (upper block of rows with the results) and between 2011 and 2021 (central block of results) produced by applying such estimators are reported in Table 2:

Table 2. Estimation results: Average Effect of coal mines closures on population change, mean annual growth rates (%), different periods.

			Raw sample	*Matched*
Number of observations (*n*)			228	456
Non-mining municipalities (control)			186	228
Mining municipalities (treated)			42	228
1991-2011	*Coefficient*	*Std. Err.*	*[95% Conf. Interval]*	
Average Treatment Effect (ATE) of mine closures	-0.454***	0.155	-0.756	-0.149
2011-2021	*Coefficient*	*Std. Err.*	*[95% Conf. Interval]*	
Average Treatment Effect (ATE) of mine closures	-0.371***	0.089	-0.545	-0.196
Placebo period: 1970-1991	*Coefficient*	*Std. Err.*	*[95% Conf. Interval]*	
Average Treatment Effect (ATE) of mine closures	-0.127	0.167	-0.452	0.198

Note: *** stands for results significantly different from zero at 1%. Nearest Neighbor Matching calculated finding the four nearest (control) municipalities for each (treated) observation. / Source. Prepared by the authors using data from the Population and Housing Census of the National Institute of Statistics.

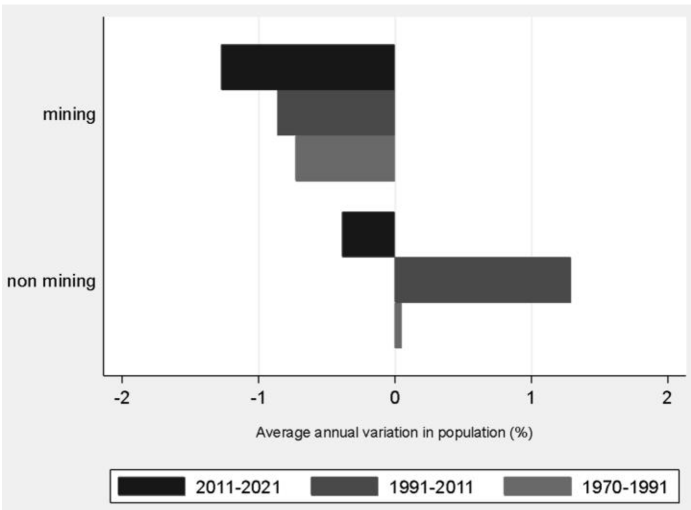
Results shown in Table 2 indicate the presence of a significant negative effect on the treatment of interest. On average, mining municipalities suffered a fall in their population between 1991 and 2011 of 0.45% annually –more than 9% accumulated in the time span considered- that, according to the NNM estimator, can be attributed to the effect of mine closures. A similar but slightly smaller effect is estimated for the period 2011-2021, with an estimate of the mean annual effect of the mine closure of 0.37% of additional depopulation due to mine closures –i.e., slightly less than 4% in a time span of ten years. Besides these point estimates of the mean effects, the matching techniques allows for doing some additional inference: under regularity conditions, the NNM estimators of the mean treatment effect distributes normally, and its variance can be estimated. Table 2 reports 95% confidence intervals for the mean effect and contains information on the outcome of significance tests, confirming the idea of the significant negative estimates of the impact of the coal mining closures in the demographic evolution of these municipalities.

4.2. A placebo analysis: 1970-1991

With the purpose of conducting an additional test on our results, we have carried out a quasi-placebo trial on the case of study. We were interested in studying what would be the results of applying an identical experiment if we analyzed the time periods not after but before the years on which the policies that cut the public subsidies started. If there were some idiosyncratic characteristics that made mining municipalities lose more population than non-mining areas, a NNM estimator applied to the period 1970-1991 should find equivalent results to those found in the period 1991-2011. If these results were not significant, these would add evidence in favor of having a statistically significant effect that could be assigned to the mine closures.

The results of this "placebo" exercise are shown in Table 2 as well (lower block of rows). The results of applying a NNM estimator with identical covariates –i.e., initial population, population 10 years before, surface and geographical coordinates- are not significantly different from zero at 5%, suggesting that there is no evidence of a significantly faster depopulation on these mining municipalities if compared with non-mining counterparts. This reinforces the idea of identifying a negative effect that can be attributed to the closures that started in the early nineties (Graph 2).

Graph 2. Average annual variation in population, different periods (%)



Source. Prepared by the authors using data from the Population and Housing Census of the National Institute of Statistics.

5. Discussion

This study has examined the impact of the closure of heavily subsidized coal mining on depopulation trends in traditionally mining-intensive areas in Spain. The findings contribute to current debates on the causes and implications of depopulation, as well as recent discussions regarding theories of the coal curse. Our analysis compares the population changes between two main time periods: 1991-2011, coinciding with the largest decline in coal production, and 2011-2021. Additionally, we replicate the same comparison using the time frame from 1971 to 1991 to verify whether the decline was more associated with a historical trend. Our results indicate that population changes before 1991 follow the same trend as other rural areas. However, the decline between 1991 and 2011 becomes more pronounced in the coal-dependent areas. Furthermore, this difference remains statistically significant in more recent years, when the public policies implemented since the 1990s were expected to take effect. Despite the public efforts in the form of tax breaks, improvements in the transport network, and the establishment of new industrial areas, former coal regions demonstrate lower resilience compared to other rural areas.

Future research should also focus on a more specific analysis of the efficiency and implications of regional development policies in mining areas. As discussed throughout this article, these areas were once beneficiaries of large amounts of public funds. In fact, the effectiveness of such policies has been called into question in various public media. For example, El Pais published an article in 2013 (Méndez & Peiró, 2013) highlighting the alleged failure of many business projects implemented in mining areas during the boom years. In it, several social leaders and local authorities discuss the failure to attract investors to industrial estates and the state of disuse of industrial parks, roads, and other public facilities. Delving into the impact of these types of policies in terms of regional development is, therefore, delving into the factors that may or may not contribute to depopulation of rural areas in Spain and Europe; but also improve the efficiency of current and future energy transition policies within the European Union.

Other areas of research that require greater attention in the future include the impact of depopulation and mining decline in terms of inequality, as well as addressing the specific characteristics of the “new mining areas” excluded from this analysis. We refer to areas impacted by the construction of large-scale power plants in the 1970/1980, which have distinct socio-economic characteristics that require dedicated examination.

References

Abadie, A., & Cattaneo, M. D. (2018). Econometric methods for program evaluation. *Annual Review of Economics, 10,* 465-503. https://doi.org/10.1146/annurev-economics-080217-053402

Abadie, A., & Imbens, G. W. (2006). Large sample properties of matching estimators for average treatment effects. *Econometrica, 74*(1), 235-267. https://doi.org/10.1111/j.1468-0262.2006.00655.x

Allcott, H., & Keniston, D. (2018). Dutch disease or agglomeration? The local economic effects of natural resource booms in modern America. *Review of Economic Studies, 85*(2), 695-731. https://doi.org/10.1093/restud/rdx042

Ayala García, A., & Abellán García, A. (2018). *La España rural se vacía.* Departamento de Población, CSIC.

Brollo, F., Nannicini, T., Perotti, R., & Tabellini, G. (2013). The political resource curse. *American Economic Review, 103*(5), 1759-1796. https://doi.org/10.1257/aer.103.5.1759

Butler, J., Wildermuth, G. A., Thiede, B. C., & Brown, D. L. (2020). Population change and income inequality in rural America. *Population Research and Policy Review, 39,* 889-911. https://doi.org/10.1007/s11113-020-09606-7

Carbonaro, G., Leanza, E., McCann, P., & Medda, F. (2018). Demographic decline, population aging, and modern financial approaches to urban policy. *International Regional Science Review, 41*(2), 210-232. https://doi.org/10.1177/0160017616675916

Cattaneo, M. D. (2010). Efficient semiparametric estimation of multi-valued treatment effects under ignorability. *Journal of Econometrics, 155(*2), 138-154. https://doi.org/10.1016/j.jeconom.2009.09.023

Díaz Morlán, P., & Escudero, A. (2012). La nacionalización de la compañía del RIF. In A. Carreras & J. Nadal (Eds.), *La industrialització i el desenvolupament econòmic d’Espanya,* (pp. 891-903). Edicions Universitat Barcelona.

Esposito, E., & Abramson, S. F. (2021). The European coal curse. *Journal of Economic Growth, 26,* 77-112. https://doi.org/10.1007/s10887-021-09187-w

European Union. (1993). *Council Directive 93/76/EEC of 13 September 1993 to limit carbon dioxide emissions by improving energy efficiency (SAVE)*. Official Journal of the European Communities, L 237, 28.09.1993. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31993L0076

European Parliament & Council of the European Union. (2003). *Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (Text with EEA relevance)*. Official Journal of the European Union, L 275, 25.10.2003. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32003L0087

European Parliament & Council of the European Union. (2010). *Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (recast)*. Official Journalof the European Union, L 334, 17.12.2010. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32010L0075

Fernández, I. del R. (2000). How costly is the maintenance of the coal-mining jobs in Europe? The Spanish case 1989-1995. *Energy Policy, 28*(8), 537-547. https://doi.org/10.1016/S0301-4215(00)00042-2

Franklin, R. S. (2020). I come to bury (population) growth, not to praise it. *Spatial Economic Analysis, 15(*4), 359-373. https://doi.org/10.1080/17421772.2020.1802056

Franklin, R. S., van Leeuwen, E. S., & Paez, A. (2018). Transportation where people leave: An introduction. *Advances in Transport Policy and Planning, 2,* 1-14. https://doi.org/10.1016/bs.atpp.2018.09.008

González Rabanal, N. (2005). Importancia de los planes de reordenación en la reconversión del carbón en España. *Pecvnia: Revista de la Facultad de Ciencias Económicas y Empresariales, Universidad de León,* 1, 67-92. https://doi.org/10.18002/pec.v0i1.742

Gradstein, M., & Klemp, M. (2020). Natural resource access and local economic growth. *European Economic Review, 127,* 103441. https://doi.org/10.1016/j.euroecorev.2020.103441

Haase, A., Bernt, M., Großmann, K., Mykhnenko, V., & Rink, D. (2016). Varieties of shrinkage in European cities. *European Urban and Regional Studies, 23*(1), 86-102. https://doi.org/10.1177/0969776413481985

Kabisch, N., & Haase, D. (2011). Diversifying European agglomerations: Evidence of urban population trends for the 21st century. *Population, Space and Place, 17*(3), 236-253. https://doi.org/10.1002/psp.600

Kalkuhl, M., Steckel, J. C., Montrone, L., Jakob, M., Peters, J., & Edenhofer, O. (2019). Successful coal phase-out requires new models of development. *Nature Energy, 4,* 897-900. https://doi.org/10.1038/s41560-019-0500-5

Kotenko, S., Shvindina, H., & Heiets, I. (2021). The impact of migration on the competitiveness of the region and industry development. *E3S Web of Conferences, 307,* 02003. https://doi.org/10.1051/e3sconf/202130702003

Lamela, C., Cardesín, J. M., & García Docampo, M. (2014). *Dinámicas territoriales en España: Problemas y tendencias en la estructura y ordenación del territorio.* Nueva Biblioteca.

Méndez, R., & Peiró, P. (2013). Sinking money into a pit. *El País. Available in: https://is.gd/ov5edv*

Nadal, J. (1975). *El fracaso de la revolución industrial en España.* Ariel.

Navamuel, E. L., Rubiera Morollón, F., & Moreno Cuartas, B. (2018). Energy consumption and urban sprawl: Evidence for the Spanish case. *Journal of Cleaner Production, 172,* 3479-3486. https://doi.org/10.1016/j.jclepro.2017.08.110

Newsham, N., & Rowe, F. (2023). Understanding trajectories of population decline across rural and urban Europe: A sequence analysis. *Population, Space and Place, 29*(3) e2630. https://doi.org/10.1002/psp.2630

Pérez-Sindín, X., & Van Assche, K. (2020). From coal not to ashes but to what? As Pontes, social memory and the concentration problem. *Extractive Industries and Society, 7(3), 882-891.* https://doi.org/10.1016/j.exis.2020.07.016

Pérez-Sindín, X. S. (2021). Energy megaprojects and social disruption: Examining empirical evidence from the surroundings of the largest power plant in Spain. *Energy Research & Social Science, 80, 102229.* https://doi.org/10.1016/j.erss.2021.102229

Poot, J. (2008). Demographic change and regional competitiveness: The effects of immigration and ageing. *International Journal of Foresight and Innovation Policy, 4,* 129-145.

Pužulis, A., & Kūle, L. (2016). Shrinking of rural territories in Latvia. *European Integration Studies,* (10), 90-105. https://doi.org/10.5755/j01.eis.0.10.14988

Reinoso Moreno, D., & Sancho Comíns, J. (2011). Una contribución activa al desarrollo rural. *Ministerio de Medio Ambiente y Medio Rural,* Madrid.

Rentier, G., Lelieveldt, H., & Kramer, G. J. (2019). Varieties of coal-fired power phase-out across Europe. *Energy Policy, 132,* 620-632. https://doi.org/10.1016/j.enpol.2019.05.042

Rodríguez-Martín, N. (2021). 'Ni luz, ni carbón, ni autoridad'. La crisis del alumbrado público y del suministro de gas en Madrid durante la primera guerra mundial. *Historia Social, 101,* 23-42.

del Rosal Fernández, I. (2004). La reconversión del carbón, una dependencia plena de la decisión pública. *Economía Industrial,* (355-356), 155-166.

San Juan, C., & Sunyer, C. (2020). Rural depopulation and income convergence. *Economía Agraria y Recursos Naturales, 19*(2), 29-48. https://doi.org/10.7201/earn.2019.02.02

Sánchez Melado, J. (2007). La minería leonesa del carbón durante la autarquía. *Estudios Humanísticos. Historia, 6,* 245-271.

Sanz-Hernández, A., Ferrer, C., López-Rodríguez, M. E., & Marco-Fondevila, M. (2020). Visions, innovations, and justice? Transition contracts in Spain as policy mix instruments. *Energy Research & Social Science, 70,* 101762. https://doi.org/10.1016/j.erss.2020.101762

Spanish Government (2007) Royal Decree 1112/2007, of August 24, establishing the aid regime for the development of infrastructure in the coal mining regions. Official Gazette of the Spanish Government (BOE), No. 207, August 30, 2007.

Sudriá, C. (1992). El instituto nacional de industria y la crisis del carbón (1960-1989). *Áreas. Revista Internacional de Ciencias Sociales,* 215-232.

Sudriá, C. (2001). La economía española bajo el primer franquismo: La energía. *VII Congreso de La Asociación de Historia Económica.*

Ubarevičienė, R., van Ham, M., & Burneika, D. (2016). Shrinking regions in a shrinking country: The geography of population decline in Lithuania 2001-2011. *Urban Studies Research, 2016,* 1-18. https://doi.org/10.1155/2016/5395379

UGT, & CCOO. (2015). *La minería del carbón y las comarcas mineras desde 1986 hasta, y después, de 2019 en España.* Madrid.

Vega Crespo, J. (1994). La reordenación de la minería leonesa del carbón: Causas y consecuencias. *Anales de Estudios Económicos y Empresariales, 9,* 357-382.

Wojewodzka-Wiewiorska, A. (2019). Depopulation in rural areas in Poland – Socio-economic local perspective. Research for Rural Development, *2*, 126-132. https://doi.org/10.22616/rrd.25.2019.059

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Annexes

Annex 1. Suitability of NNM

One important question for implementing matching techniques, which differentiate several specific variants, regards the definition of the criterion of similarity between units. NNM specifies this criterion by defining a multidimensional concept of similarity based on distances between a set of observable covariates for each unit (municipalities). Consequently, cases can be matched based on these differences between the relevant characteristics of the units.

We applied NNM to our sample of 228 municipalities, taking as outcome of interest the population growth rate in each period time considered. In our framework the municipalities classified as "mining-intensive" are the treated units, while the non-treated are the rest of municipalities within the same province. The observables on which we condition the matching are the logs of the initial population and the population 10 years before, the surface and the geographical coordinates. One important issue for a successful application of matching techniques is that the covariates are balanced across treated and non-treated units. Table A.1 displays a summary of the balance indicators for the covariates considered before and after the matching, suggesting a better-balanced dataset after the matching procedure with (standardized) mean difference closer to zero after this procedure for all the covariates.

Table A.1. Balance in the covariates prior and after the NNM matching

	1991-2011		*2011-2021*		*Placebo: 1970-1991*	
Standardized differences	Raw sample	Matched	Raw sample	Matched	Raw sample	Matched
Initial population (in logs)	0.963	0.596	0.908	0.513	0.983	0.645
Population lagged 10 years (in logs)	0.977	0.597	0.932	0.532	0.990	0.655
Surface	0.722	0.378	0.722	0.359	0.722	0.439
East-West coordinates	-0.106	0.014	-0.106	0.019	-0.106	0.020
North-South coordinates	0.396	0.172	0.396	0.171	0.396	0.178

Note: standardized differences refer to the mean differences between mining and non-mining municipalities in the covariates normalized by their standard deviation) before (Raw sample) and after (Matching) applying NNM. / Source. Prepared by the authors using data from the Population and Housing Census of the National Institute of Statistics