University of Ioannina
Department of Economics

Master Thesis

The Role of Agricultural Subsidies in Shaping the Population Growth of Rural Communities in Greece

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Acknowledgment

To my beloved parents, who have always inspired and supported me throughout this journey and have never stopped being a fundamental part of my successes.

Abstract

This study introduces a different perspective on the depopulation challenge in Greek communities, emphasizing in the influence of agricultural subsidies on population growth rate in rural areas. Census reports exposed a consistent decline in the Greek population, accompanied by the abandonment of the agricultural sector and the trend of urbanization. The research adopts a mixed methods approach, employing linear regression models to quantify the relationship between subsidy growth and population growth through Ordinary Least Squares (OLS) estimation. The findings indicate a positive correlation between subsidies and population growth, along with a negative impact associated with the altitude of a community. A classification method is also used, specifically the K-Means algorithm, in order group the communities and investigate the similar behavior. For the first time, this study examines the behavior of island communities from the perspective of agricultural subsidization, uncovering distinct behaviors compared to mainland regions. Finally, the elasticity of population concerning agricultural subsidies (efficiency index) for each community is computed and compared with the neighbor possessing the longest border length among all neighbors associated with each community. Using this approach, it is found that communities with the most substantial reduction are likely to experience the most significant increase in population growth.

Keywords: Agricultural Subsidies, Population Change, Cluster Analysis, Linear Regression, Rural Communities, Policy Implications.

Chapter 1

Introduction

1.1 Preliminary Remarks

Agriculture has played a pivotal role in shaping Greece's national economy for several decades. Over time, a notable shift has occurred, with an increasing number of individuals relocating from rural areas to urban centers such as Athens and Thessaloniki in pursuit of educational and career opportunities. As a result, these metropolitan areas experienced substantial population growth, while rural development stagnated. From economic perspective, the economy's primary focus shifted from agriculture and farming industries to a more modern, service-oriented sector that defines today's society.

The significance of the agricultural sector has been duly recognized by the Greek Ministry of Rural Development and Food (GMRDF), which is responsible for fostering agricultural development and revitalizing rural areas. In pursuit of these objectives, the Greek State has implemented diverse policies aimed at enhancing the well-being of rural inhabitants, encouraging settlement in these regions, and alongside enhancing the productivity and competitiveness of the agricultural sector. With direct payments to producers, the European Union (EU) and the GMRDF are helping the countryside to be reconsidered as a choice for life of the new generations.

This thesis focuses on a quantitative study examining the influence of agricultural subsidies on population change within local communities, particularly rural areas. The research aims to identify factors contributing to varying effects observed across regions. The first chapter introduces agricultural subsidies in Europe and the Greek agricultural environment. Chapter two provides a literature review to support the research question. Chapters three and four cover data characteristics and research methodology respectively. Chapter five presents the data analysis answering the main question and also many sub-questions that occurred, and chapter six provides the conclusions of this study, summarizing findings and implications for sustainable rural development .

1.2 Agricultural Policy in Europe

The EU has gradually intensified its focus on the agricultural sector, with initial steps being taken shortly after the end of World War II. In 1962, the EU introduced the concept of a reformed Common Agricultural Policy (CAP). Initially, CAP was primarily aimed at enhancing the food quality consumed by European citizens. However, the program's focus revolved around supporting the primary products market. This approach underwent a significant transformation in 1992, as the emphasis of the support shifted towards producers. Price support was gradually reduced, and instead, direct payments were introduced to benefit farmers (see Publications Office of the European Union (2017)).

Policies enacted prior to 1992 were characterized by interventions that aimed to maintain stable prices for agricultural products and guaranteed income for farmers. This was often tried to achieved through mechanisms such as price support, production quotas, and import tariffs, which sought to balance supply and demand in agricultural markets. The primary goal of this revised CAP was to invigorate the European agriculture activity, fostering its dynamism, competitiveness, and efficiency.

The policy governing the agricultural sector within the European territory is built upon ten essential objectives, each playing a significant role in shaping the future of European agriculture. These objectives encompass a wide range of aspirations, including ensuring a fair income for farmers and empowering farmers within the food chain. Additionally, the policy addresses critical issues such as climate change action, environmental care, and the preservation of precious landscapes and biodiversity.

Moreover, the EU's agricultural policy places emphasis on supporting generational renewal and invigorating rural areas, recognizing their vital contributions to sustainable development which simultaneously promotes the population expansion in country side areas.

Ensuring the quality and safety of food and health is another pivotal objective, as the EU strives to maintain high standards for its citizens. Lastly, the policy seeks to promote knowledge and innovation throughout the agricultural sector, fueling progress and adaptation to changing needs and challenges.

With these ambitious objectives, the EU aims to pave the way for a more dynamic, competitive, and responsive European agricultural sector in line with its vision for sustainable, smart, and inclusive growth.

The agricultural sector is unique and stands apart from most other economic sectors as it receives almost exclusive support from the EU, while other sectors typically fall under the responsibility of national governments. The overarching objective of the CAP is to enhance the well-being and livelihoods of farmers.

In contrast, when it comes to agricultural products, there exists a unified European market, where a harmonized approach to supporting agriculture ensures equitable conditions for farmers engaged in both the internal European market and global trade. This collective effort fosters fair competition and contributes to a thriving agricultural industry within the EU and on the global stage.

All the Member States share these objectives, also known as pillars. The first pillar reflects to direct support and market measures and the second reflects on rural development. EU states that *"There can be no doubt that without a common policy, each EU Member State would proceed with national policies with variable scope and with different degrees of public intervention"*. It is noteworthy that, the significance of agriculture has been acknowledged and even elevated however, over the period of 30 years, the budget allocated to the sector has exhibited a declining trend from 75 percent down to almost 40 percent (see Publications Office of the European Union (2017))[1]but that does not mean the effectiveness of the program is decreased.

1.3 The Timeline

The CAP has a rich history that has demonstrated significant progress while also learning from its mistakes. Over the past 55 years, (see European Council (2023))[2]the EU has placed considerable trust in the agricultural sector, and farmers, in turn, hold a positive attitude towards the EU. Throughout this period, there have been numerous remarkable achievements and several revisions. However, only seven key milestones, including its inception, deserve deeper examination due to their significance in shaping the policy's trajectory.

In 1968, the European Communities established the first set of targeted objectives for farmers and also talked about a "common approach to agriculture" , which were as follows:

- Increasing agricultural productivity
- Ensuring a fair standard of living for farmers
- Guaranteeing the availability of supplies
- Stabilizing the markets
- Establishing a secure supply chain with reasonable prices
- Harmonizing competition rules across all countries

[1]The budget per farm is even lower if someone consider that during the 30 year period 18 new Member States have joined the Union (more than doubling the number of farmers).

[2]For a comprehensive and detailed timeline of the Common Agricultural Policy milestones and timeline, please refer to the Council of the European Union website under the Home/Policies/Common Agricultural Policy section which provides an in-depth review of each milestone.

To attain these aims, the CAP established an economic system of price and market support. This mechanism provided farmers with a guaranteed price for their products, imposed tariffs on external products, and allowed state intervention in case of market price fluctuations. Farmers received support based on their levels of production. Over time, the CAP has witnessed remarkable progress, particularly during the period when direct payments were introduced and beyond.

In 1970, the first reform took place, known as *"The Mansholt Plan,"* initiated by Sicco Mansholt, the European Commissioner for Agriculture. This modernization effort aimed to increase agricultural productivity and enhance the supply chain, while also ensuring stable farmer incomes despite increased productivity. The plan proposed optimizing cultivated land areas and merging farms to create larger units.

By 1984, agricultural production had surpassed demand, resulting in lower product prices or wastage. To address this issue and stabilize farmer incomes during periods of low demand, the EU introduced a *"quota system"* limiting the maximum production of each individual farmer.

In 1992, the first major-scale reform of the CAP occurred, shifting from market support to direct income support for farmers. This marked the introduction of direct payments to farmers for the first time.

Subsequently, in 1999, the EU focused on rural development, as the agricultural sector provided limited opportunities for new job creation. The "Agenda 2000" led to the establishment of the "Second Pillar," offering new approaches to rural development and emphasizing the significance of providing alternative sources of income for these areas.

In 2013, the new CAP addressed emerging concerns related to climate change and sustainable use of natural resources. The reform aimed for a greener agricultural sector, equal distribution of support among small and large farmers, and motivation for young individuals to pursue careers in farming. Furthermore, significant projects for local entrepreneurship were planned to enhance rural development.

At present, we are in the period of the newest reform for 2023-2027 titled *"A Fairer, Greener, and More Result-Oriented Policy."* This new CAP continues to support environmental and climate laws, providing incentives for greener practices. It also prioritizes smaller farms and young farmers by offering them more support.

Summarizing the timeline above, we see a series of policy developments and reforms but an overall progress. Its objectives include enhancing agricultural productivity, supporting farmers' livelihoods, ensuring supplies, stabilizing markets, establishing a secure supply chain, and harmonizing competition rules among member countries. This policy continues to adapt and to address new challenges like climate change, aiming to foster the agricultural sector in line with the EU's vision for sustainable and inclusive growth.

1.4 Rural Development

Approximately half of the European Union's population resides in rural areas (see Publications Office of the European Union (2017) p. 10), where the sustenance and cohesion of numerous communities heavily rely on the agricultural sector, as it assumes a pivotal role in supporting and preserving these localities. However, it is evident that employment within this sector has been experiencing a decline, and notably, the average age of individuals residing in rural areas shows an increasing trend. This demographic shift raises concerns, as fewer and older individuals are continuing to sustain the farming industry each year.

Within the comprehensive framework of the policy, encompassing ten key objectives, two of them particularly emphasize robust support for rural areas across the EU. The first objective aims to facilitate the renewal of generations and the second objective is centered around fostering the knowledge on people working in agricultural sector.

Designing rural development policy is not always an easy task, it involves numerous unique challenges that can lead to unintended consequences contrary to the initial intentions. Recent studies also analyze the risks associated with policies like the CAP, which encompass the development and innovation projects of the countryside. Risk analysis provides another perspective to the main point which is *"Rural Development"*. The Díaz-Puente et al. (2022) reveals that rural projects and initiatives encounter significant risks, primarily within the social realm, forming a crucial foundation for interactive innovation. Lastly, it observed a correlation between political-legal risk factors and the coordinating country of the project.

In its early stages, the "*Agenda 2000*" introduced distinctive policies that sparked a considerable debate among members of the European Council regarding their future effectiveness, as observed in the work of Saraceno (2003)[3]. These discussions centered around two divergent viewpoints. The first perspective emphasized that all Member States shared common objectives and instruments aimed at facilitating the transfer of resources from the market to producers. However, it was acknowledged that different regions within these Member States have different needs and requirements, so a common policy isn't so efficient across the Europe.

Conversely, the second argument suggested that the overarching goal of enhancing the rural economy was too uniform across all Member States. However, it was noted that insufficient consideration had been given to the unique natural strengths and weaknesses in each rural region at that time. This lack of recognition for regional disparities was seen as a potential limitation in achieving optimal outcomes for rural development.

[3] Saraceno's study on rural development offers significant recommendations for improving the efficacy of diverse rural development policies. Interestingly, the study emphasizes the environment years before the EU's environmental reform, stating that *"All the rural population should be in principle eligible to realize environmental services and public goods." This indicates the study's early recognition of the importance of ensuring environmental benefits and services for all rural communities.*

The examination of the impact that CAP has on rural areas and development creates a significant aspect in the evaluation of this agricultural policy. A notable challenge arises when assessing the actual attainment of rural development goals, as both the European Commission (EC) and the individual Member States have not provided comprehensive evidence of the progress made towards these objectives. Consequently, this lack of transparency gives rise to uncertainties regarding the effective allocation and utilization of the EU budget, as discussed in Papadopoulos A. (2015)[4].

One significant challenge encountered by rural policies, such as the CAP, relates to the uneven distribution of subsidies, particularly from the perspective of farmer size. Notably, smaller-sized farms, which rely heavily on production and generally have lower incomes, have received comparatively smaller subsidies.

On the flip side, farmers with larger hectares of land have benefited significantly more through rural development subsidies, as also highlighted in Papadopoulos A. (2015). This discrepancy raises concern, especially since the primary objective of the second pillar is to ensure an equitable distribution of funds among farmers, with a particular focus on supporting young and low-income farmers and a parallel rural development.

Rural development initiatives within the CAP can be viewed as contributing the improvement of agricultural labor or the diversification of employment opportunities within the agricultural sector. Empirical investigations such as Garrone et al. (2019) indicated that CAP subsidies, primarily originated for the first pillar, exhibit an average reduction in labor outflow. In contrast, payments originating from the second pillar manifest mixed effects on labor migration patterns.

Further more according to the estimates from the same study, a 10 percent increase in the CAP budget would prevent an additional 16,000 departures from the EU agricultural sector annually. Nevertheless, it is important to acknowledge that such preventive measures entail a substantial cost, amounting to approximately 300,000 EURO per year per preserved job in the agriculture domain. These findings underscore the intricate relationship between CAP subsidies and labor dynamics in the agricultural sector, as documented in relevant studies.

Besides, it is also important to consider the mechanism through which the agricultural policy influences the productivity of the farming sector, as this mechanism can significantly influence the impact of subsidies, leading to either positive, negative, or mixed effects.

[4]In the study by Papadopoulos A. (2015), various reasons are presented that shed light on the program's inefficient monitoring of progress. The research also highlights the significant criticism faced by the CAP, particularly concerning the unequal distribution of assistance to farms of varying sizes. Indeed, agricultural subsidies have faced criticism for their potential disruption of the overall market dynamics and their impact on labor reallocation.

As demonstrated in Marian et al. (2013), subsidies had a negative impact on farm productivity before the implementation of the decoupling reform[5]. However, following the decoupling, subsidies were found to have a positive effect on productivity in several countries . Moreover, variations in empirical findings among different studies may be attributed to differences in geographic boundaries that each study encompasses, which could introduce unique contextual factors that influence the observed effects of subsidies.

Upon reflection, when the state of rural areas in the past is compared with their current condition, a remarkable transformation becomes evident, attributable in part to policies like the CAP. The undeniable truth is that rural regions have witnessed substantial progress and enhancement, not only in agricultural productivity but also in socio-economic indicators.

The provision of essential services, such as internet connectivity, has contributed to a decline in poverty rates and a rise in employment opportunities and thus, some of the CAP objectives have been achieved. As a result, rural areas now present a more favorable and promising outlook. While examining the growth of European rural areas researchers found that CAP has been successful to some extend in increasing employment rate and Gross Domestic Product (GDP) per capita as well as decreasing poverty rate, so the broader perspective reveals a positive trajectory for these regions (see Grodzicki T. and Jankiewicz M. (2022)).

An important goal that the CAP has yet to fully achieve is effective knowledge transfer and innovation within the agricultural sector, which poses constraints on rural development. Initiatives like LEADER[6]in the European Union came to assist CAP on rural development, aiming to recognize and support exemplary leaders in rural communities and encourage other farmers to follow their lead to enhance productivity and overall improvements. The European Union had planned to allocate approximately 7.010 million EURO as the "European Agricultural Fund for Rural Development" during the 2014-2020 period. Despite the amount of funds allocated to such programmes, significant success in attaining their stated objectives remains limited, as indicated in European Court of Auditors (2022). Moreover, the challenges faced in progressing with policies like this are not novel, as seen in Bonfiglio et al. (2017), where authors noted an uneven and sometimes low uptake of available opportunities for knowledge transfer.

[5]The "decoupling reform" refers to a significant policy change in the European Union's CAP that was implemented in the early 2000s. Before the decoupling reform, farmers received direct subsidies linked to the production levels of specific agricultural commodities. In other words, the amount of subsidy a farmer received was tied to the quantity of crops or livestock they produced. The decoupling reform aimed to separate these direct subsidies from actual production.

[6]LEADER and Community Led Local Development (CLLD) present a distinctive approach that integrates the elements of a local area, partnership, and development strategy. The focus is on creating a positive vision for the area, backed by active collaboration among local stakeholders. Unlike a project-based approach, funding targets the overall priorities of the entire area, not specific projects or groups. The eligibility for LEADER programs is determined by population of around 10,000 to 150,000 inhabitants, with potential additional criteria specific to each Member State. The area's boundaries may be adjusted as the strategy and partnership evolve based on development priorities and stakeholder involvement (see more in European

1.5 The Case of Greece

Throughout its history, Greece has consistently relied on its agricultural sector and livestock farming as the cornerstone of its economy. Notably, Greek agriculture holds a substantial share, among other sectors, contributing 4.3 percent to the national GDP, a figure nearly double the European average. The emergence of Greece's primary sector dates to 1915, marked by the adoption of a cooperative farming system that has since evolved into a pivotal driver of the contemporary economy. Quantifying the significance of Greece's primary sector, particularly agriculture, approximately 31.9 percent of the total population lives in agricultural areas. Furthermore, its contribution to employment is equally remarkable, accounting for 10 percent of the total labor force (see European Commission (2023)), a figure that distinguishes it significantly from the European average which is lower by about 6 percentage points.

Greece encounters numerous challenges within its agricultural sector. One prominent issue is the shortage of skilled professionals in agriculture, minimizing the potential for growth and advancement in the farming industry. Nearly 5.5 percent of the total farmer population has obtained certification, indicating a limited pool of expertise. Furthermore, a significant challenge lies in the condition of the land itself. Roughly 70 percent of the utilized farmland falls under the classification of "*Area with Natural Constraints*".

This designation signifies that the Greek landscape poses inherent difficulties for agricultural cultivation due to natural factors, further complicating the farming landscape. In conclusion, the agricultural landscape in Greece comprises approximately 709.500 farms, with the average farm covering less than 2 hectares. While there is a plethora of implications of this statistic, it is noteworthy that these farms collectively provide employment for around 400,000 households and thus, the agricultural sector wields a significant social influence within the country.

There are several issues arising from the inadequate training of Greek farmers. Firstly, the lack of proper training makes it challenging for the labor force to adapt to new technologies and adopt practices that are essential for the next generation of farming. Technologies like farm-monitoring drones or precision farming methods[7]might not be effectively utilized by Greek farmers due to a shortage of trained individuals in these areas. Recent studies such as Lakasas Y. (2022) found that the majority of farmers are recognizing the negative consequences of having an untrained labor force and this recognition is a positive outcome because a big problem is identified. However, it's worth noting that young farmers are more enthusiastic about learning agricultural science, embracing new technologies, and being part of the innovative future of farming.

Network of Rural Development (2022)

[7]Precision Agriculture is a modern farming approach that leverages technology like GPS, sensors, and data analytics to optimize crop production. By collecting and analyzing data on factors such as soil conditions and crop health, farmers can make informed decisions about planting, fertilization, and pest control. This precision-based strategy increases yields, reduces resource waste, and promotes sustainable farming practices.

The recent reform of CAP, for Greece reflects a pronounced shift towards prioritizing sustainability and organic agriculture. Notably, the period between 2000 and 2007 witnessed a remarkable surge of 885 percent in organic farming in Greece, marking the highest percentage increase across the EU. This surge underscores the increasing recognition of organic practices to achieve environmentally conscious and ecologically balanced agricultural systems, aligning with the broader EU sustainability objectives.

Considering the latest Greek CAP (see European Commission (2023))[8]proposal and especially the plan for rural development, several significant points worth attention. Firstly, a substantial sum of 791 million EUR will be dedicated for the advancement of agricultural enterprises, underscoring a commitment to bolstering the agricultural sector's productivity and competitiveness. Additionally, an allocation of 551 million EUR is designated for agri-environmental and climate-focused initiatives, exemplifying the growing emphasis on adopting practices that mitigate environmental impact and promote climate resilience. Moreover, an allocation of 513 million EUR is dedicated to fostering local development through LEADER initiatives and community-driven endeavors, highlighting the importance of empowering local communities to play an active role in shaping their region's agricultural and economic landscape.

These allocations collectively underscore a discernible emphasis on rural development, sustainability,and climate action within the framework of Greece's agricultural policy. As the nation looks to the future, these policy shifts represent a strategic effort to align agricultural practices with broader societal and environmental priorities, ultimately contributing to a more resilient and balanced agricultural sector.

A strong indication from EC revealed that approximately 5 percent of the total farmers are less than 35 years old which is another big is issue of Greek agriculture. With the aim of fostering a renewed demographic number within the agricultural sector and ensuring sustainable progress in rural regions, Greece is set to allocate a sum exceeding EUR 730 million towards facilitating young farmers. This initiative will be complemented by comprehensive measures targeting their education, provision of advisory support, and enhancement of their entrepreneurial blueprints. Additionally, in pursuit of improving social development, local advancement, and gender parity, particularly increasing the participation of women in agriculture, Greece will actively foster the growth of local enterprises and amplify investments to fill-up the needs of the resident populace. Special attention will be directed towards endeavors of a social and environmental nature.

[8]The European Commission provides extensive fact sheets encompassing a range of policies across the European Union. For a more detailed and comprehensive understanding of the latest CAP reform, including the full CAP Plan for the years 2023-2027, please consult the available fact sheet. European Publication Office (2023)

1.6 Population Change

In terms of population change, Hellenic Statistical Authority (HSA) provides a very clear image of the demographic growth through the *census reports*[9] (see Hellenic Statistic Authority (2023)) which are published every 10 years. More specifically, the decade 2011-2021 HSA found a decrease in population approximately 3 percent, something concerning because this affects every socio-economic pillar. A continuously downward trend in population growth could lead to an aging population, resulting in challenges for healthcare and pension systems, labor force shortages, reduced economic activity, fiscal pressures on welfare programs, and disparities between urban and rural areas. Cultural and social dynamics might shift, while the housing market could be affected. Policy considerations must focus on stimulating growth and promoting innovation, and there could be potential environmental benefits alongside economic and demographic challenges.

This population decline can be attributed to various interconnected factors, many of which are linked directly to Greece's economic condition over the past decade. The economic recession of 2008 escalated into a debt crisis, profoundly impacting essential economic and social dimensions such as income, pensions, poverty, unemployment, social exclusion, housing, savings, and meeting basic daily necessities. This crisis compelled the population into a more constrained way of life. As indicated by Mavridis S. (2018), Greek GDP plummeted by as much as 25 percent, the national debt remained elevated, and the daily lives of people, particularly the youth, became significantly challenging, prompting a substantial emigration of young individuals abroad for economic reasons, also known as brain drain. Concurrently, there has been a consistent decline in the population under the age of 15, partly due to the high cost of living.

As observed, the decline in the number of younger individuals has exerted a significant influence on the prospective cohort of farmers in Greece. The agricultural workforce has aged notably rapidly, and the absence of efforts to lower this age threshold has intensified the situation. This serves as one of the primary drivers behind the strategic focus of the GMRDF on rural area development, with the goal of enhancing the quality of life in these regions. The next chapter will present a comprehensive literature review that delves into the research question, providing a more focused exploration of the intricacies surrounding this phenomenon.

[9]Hellenic Statistical Authority (HSA) in 21.4.2023 published the final results on census report of 2021 for every rural community and every NUT level in Greece, small changes may be occur from HSA's corrections in the final report.

Chapter 2

Literature

2.1 Introductory Notes

The origin of the *"Municipal Community"* concept in Greece can be traced to the initiation of the 2010 Kallikratis Program, designed to reform local governance. This term refers to a subset within larger municipal units, formed by combining former municipalities called *"OTAs*." These resulting units, part of new municipalities, maintain the original names. This administrative reshaping, crucial to Greek governance restructuring, introduced key elements. These encompass local/municipal departments with populations exceeding defined thresholds, merged municipalities and communities resulting from stipulated combination, and distinct local units within populous island settings. Crucially, the composition of a municipal community extends beyond demographics, encompassing entities that include islands and lack independent municipal status. However, certain exceptions are applied, particularly for larger municipalities with densely populated municipal departments.

Therefore, the fundamental aim of this thesis is to assess the influence of agricultural subsidies on population trends within Municipal Communities across all regions of Greece, and endeavor to categorize these communities based on similarities in the observed impacts in order to identify patters that will be helpful shaping the next agricultural support for Greece. To the best of my knowledge, there appears to be no parallel case study pursued for Greece within the research community that shares the same objectives as this thesis. The nearest resemblance to the scope of this research lies in the policy assessment of CAP initiated by the EU or the independent evaluation that GMRDF to the second pillar of CAP, aiming to gauge the effectiveness of various policies. So this attempt seeks to address an unrecognized path in the existing *research landscape*[1].

[1]The existing literature extensively addresses inquiries pertaining to agricultural subsidies, predominantly focusing on their effectiveness in terms of productivity (input-output analysis). However, this study distinguishes itself through its analytical depth, specifically centered around the regional level of analysis.

2.2 Impacts on Population Dynamics

Several studies have been conducted to offer insights into the demographic dynamics of Greek prefectures, analyzing population redistribution across urban and rural gradients during economic expansions and recessions. In Salvati L. (2018) through multidimensional statistical techniques, the research uncovers a complex territorial patchwork influenced by various socioeconomic processes at different scales, including global demographic shifts, national-level recession outcomes, and local-scale suburbanization and re-urbanization cycles. More specific, the study identified contrasting population growth patterns during economic expansion and recession. Expansion saw growth in urban centers with distant economic functions, while recession led to growth in coastal tourism-focused areas with moderate accessibility and population density. The interesting part is that income levels and changes over time had no influence on population re-distribution over Greek prefectures, indicating a substantial decoupling of demographic growth from income growth.

Within the realm of population distribution, a notable trend surfaces revealing a preference for relocating to medium-sized cities or regions in Greece. This trend aligns with Polinesi et al. (2020) observations, unveiling non-linear connections between demographic growth rates and population density. Moreover, a temporal shift is evident moving from density-driven urban growth to analogous patterns in medium-sized cities and accessible rural regions. This exploration illuminates the role of population concentration and dispersion over extended demographic assessments. Importantly, the research indicates positive effects in early decades, contrasting with negative effects later. Crucially, a key finding underscores gradual depopulation in marginalized rural zones, emphasizing rural decline's influence on unstable demographic patterns and underlining the urgency for enhanced strategies to counteract depopulation in highly rural regions.

Summing up, population change in Greece has been influenced by economic cycles, with periods of expansion and recession impacting demographic structures (see Salvati L. (2020), Salvati L. (2018), Pierrakos et al. (2019)). The country experienced a shift towards an aging population, mono-nuclear families and increased immigration during the economic expansion in the early 2000s as demonstrated in Federico et al. (2019). However, the subsequent recession led to changes in traditional family structures, out-migration to northern and western European countries, and reduced immigration from developing countries as concluded in Salvia et al. (2020). There is substantial heterogeneity in demographic processes across Greek regions, with metropolitan areas and coastal districts experiencing rapid population dynamics, while peripheral rural regions undergo moderate population aging. The recession has had a short-term impact on population structures, leading to a rapid increase in the median population age, which may have negative consequences for the country's economic recovery. The population redistribution during the recession was influenced by factors such as the presence of urban centers, tourism specialization, and accessibility, rather than income levels.

2.3 Rural Areas and Agriculture

Municipal communities in Greece have gathered attention in a range of studies, each offering distinct viewpoints and a unique perspective. For instance, in Metaxas et al. (2017) introduced a model aimed at elevating service quality by measuring citizen satisfaction, The insights that can be derived from the model will carry significant policy implications, concerning the capacity and role of local authorities and decision-makers in delivering effective and functional services to their respective communities. Additionally, studies have completed an exploration of various local networks in Greece searching their influence on state-society relations, in Getimis P. (2021) is found that *these networks*[2] embody incomplete institutionalization processes. However, new challenges occur from traditional ways of organizing government-society connections that are based on hierarchy, fragmentation, and favoritism[3].

More focused studies have been dissected the interplay between urban expansion, population dynamics, and municipal areas in Athens, underscoring the pivotal role of municipal size in the equitable distribution of services and infrastructure. In Ciommi et al. (2020) the empirical findings show that in big city areas, the size of municipalities is becoming more in line with how many people live there. This helps spread out the population more evenly. This pattern was made stronger by the recent changes in how local governments work in Greece.

Assessing the aftermath of the *Kallikratis program*, the Pazarskis et al. (2019) showcases that despite decreased state support, certain municipalities have achieved enhanced financial outcomes and depending on the location, some towns got more advantages from the required merging of municipalities than others. They had better capital management, less responsibilities, and improved their financial situation. This gives us new information about how areas in Greece are developing locally. In closing, there is a focus on Athens' local communities, highlighting the importance of involving citizens and stakeholders in participatory planning to improve urban life which translate to the participatory planning framework can lead to more qualitative outcomes and cooperative, highly inclusive decision-making processes (Stratigea et al. (2017)). Together, these inquiries shed light on various facets of Greek municipal communities, encompassing service quality, state-citizen connections, urban evolution, financial performance, and citizen participation.

[2] About the network the author states *"The Greek case of local networks includes an analysis of municipal advisory committees, councils for the integration of migrants and refugees, school committees, and local development agencies. These networks can be seen as typical for local state-society relations in Greece, representing variance along the three suggested analytical dimensions of autonomy, group coherence, and relevance in local policy-making."*

[3] Favoritism refers to the practice of showing preferential treatment or giving advantages to certain individuals or groups, often based on personal relationships or biases, rather than on objective criteria or fairness. It can involve giving special privileges or opportunities to someone due to personal connections or other non-merit-based reasons.

Greek agriculture is characterized by small farms dispersed across a diverse landscape, a pattern that has remained consistent over the years. Despite the financial crisis, agricultural communities in Greece have demonstrated resilience, with output rising while other sectors declined, as demonstrated by Karantininis K. (2017).

On the flip side, although there has been a surge in output, the overall contribution to the Greek economy has notably diminished over the past 15 years. The CAP has had an impact on the agricultural sector in Greece, with a reduction in the contribution of agriculture to the economy and an increase in imports of agricultural products (see Paschalidis et al. (2018)). Traditional farming practices in Greece, such as *semi-extensive farming*[4], have been found to support high levels of biodiversity at the landscape scale, in Georgiadis et al. (2021) the preliminary findings reveal that seasonal grazing, diverse habitats, small field sizes, and crop diversification, including mixed cultivation and rotation, are essential practices supporting biodiversity. Motivations, attitudes, and problems related to the adoption of conventional and organic farming in rural communities in Greece have been studied and found that, the decision to adopt organic farming is influenced more by environmental and *ideological reasons*[5] rather than economic ones (see Koutsoukos M. and Iakovidou O. (2013)).

The agricultural community in Greece has undergone significant changes over time. The transformation of Greek rural society has led to a reduction in agricultural employment and rural population, as well as socio-economic differentiation among agricultural producer, in Kasimis C. and Papadopoulos A. (2001) we see that family farms adapt to changes based on how families run their farms and government farming policies. This connects with historical migration from rural areas during global economic growth. The way farming is done has led to some farmers being better off and regions becoming more similar in terms of how they farm. Urban agriculture in abandoned municipal spaces has emerged as a means to fight poverty in certain social groups during the economic crisis. The study of Abeliotis K. and Doudoumopoulos K. (2019) highlights the potential of urban agriculture in abandoned municipal urban spaces as a viable intervention strategy for the urban poor to earn extra income.

[4]In semi-extensive farming, there is a moderate level of input and management compared to intensive farming, but it still involves more attention, care, and resources than extensive farming. This approach aims to strike a balance between maximizing yields and maintaining a degree of environmental sustainability and animal welfare. It often involves a mix of traditional and modern techniques to ensure productivity while also considering the ecological impact.

[5]Farmers who choose organic practices for ideological reasons are committed to minimizing the environmental impact of agriculture, valuing the production of food free from synthetic chemicals and genetically modified organisms. They may also advocate for higher animal welfare standards and support local economies, fostering a deeper connection between consumers and producers. Embracing organic farming can be seen as a means of preserving traditional and sustainable farming methods, resisting industrialization, and aligning with cultural or spiritual values that emphasize harmony with nature and community well-being.

2.4 The Influence of Agricultural Subsidies

Agricultural subsidies in EU have faced extensive criticism, particularly due to their role in distorting markets and favoring larger agricultural operations over smaller ones. The lack of transparency in subsidy distribution, detachment from actual market conditions, and the reliance on subsidies have also been noteworthy concerns. Research has demonstrated that CAP subsidies have had adverse effects on agricultural productivity growth, with more pronounced negative impacts observed in new member states, highlighting the policy's incompatibility with the agricultural dynamics of these regions (see Duquenne et al. (2019). Moreover, various instances from distinct member states, as exemplified by Rastislav et al. (2020) in a study of the Slovak Republic, shed light on the matter. The investigation unveiled a statistically significant linear association between farms performance outcomes and the magnitude of subsidies per hectare of agricultural land across all legal forms during the assessment period.

Additionally, this assertion gains further credence when considering other research studies, exemplified by the work of Staniszewski J. and Borychowski M. (2020), which underscores the hypothesis regarding the influence of subsidies on efficiency is intricately tied to the scale of farms. Notably, within this context, the research unveils a statistically significant and stimulating subsidy effect, a phenomenon discernible exclusively within the category of the largest farms. These intriguing findings give rise to pertinent questions concerning the overall efficacy of the CAP in terms of promoting the growth and advancement of the European Model of Agriculture.

Conversely, numerous studies have demonstrated a contrary perspective, showcasing the positive and influential impact of CAP subsidies. In Hungary and Slovenia, for instance, CAP subsidies, particularly those under Pillar I, have been found to exert favorable effects on farm employment, particularly paid labor in Hungary and family labor in Slovenia (Bojnec S. and Fertő I. (2022)). The financial support channeled through the second pillar of the CAP also plays a positive role in mitigating socioeconomic marginalization within Romanian farms and their surrounding areas (Biffi et al. (2021)). Nonetheless, the reallocation of Pillar I budgets toward a coupled agricultural labor subsidy in the EU has exhibited an employment boost within the agricultural sector. However, monitoring the funds is another issue, in (Murray et al. (2020)) authors conclude that billions in misspent EU agricultural subsidies could support the Sustainable Development Goals if redirected and better monitored. To sum up the above discussion, it can be inferred that while agricultural subsidies have shown a "negative" effect on productivity but their overall impact appears to be positive on various other dimensions within agricultural communities. However, challenges persist, with particular attention needed on effectively monitoring these policies to ensure clear and transparent observations to achieve actual development.

As seen in the introduction, the second pillar of the CAP refers to the Pillar II payments, which include measures such as human capital development, physical capital investments, agro-environmental measures, and rural development. Research suggests that Pillar II payments for physical capital investments, human capital development, and agro-environmental measures have a positive impact on agricultural productivity as concluded in Salhofer K. and Feichtinger P. (2020). However, payments related to rural development do not significantly affect productivity (see Dudu H. and Kristkova Z. (2017)). Lastly, in some cases reallocation of funds from the first to the second pillar of CAP has negative effects on gross value added and employment in agriculture, but positive effects on other sectors of the economy.

2.5 The Different Approaches

All of the various methodologies that have been employed in order to assess the efficacy of the CAP as well as the agricultural subsidies in general, share a multitude of similarities, yet they ultimately share a common objective, which is to evaluate the aforementioned policies. It is evident that researchers are frequently using different methods that actually measure the same thing, the technical efficiency. One of the most popular methodologies for assessing Technical Efficiency is by using Stochastic Frontier Production Functions (SFPF), with minor modifications made to the baseline model on each occasion (see Karagiannis G. and Sarris A. (2002), Ghorbani et al. (2020), Latruffe et al. (2017), Rezitis et al. (2002)). This *parametric method*[6] assists Decision Making Units (DMUs) in identifying potential inefficiencies within the production function, providing avenues for improvement, and incorporates both input-oriented and output-oriented approaches.

The Data Envelopment Analysis (DEA) is an equally important method that has been utilized to gauge the technical efficiency within the realm of assessing the effectiveness of diverse policies. As opposed to the parametric method known as SFA, DEA operates as a *non-parametric*[7] approach and has been extensively employed in numerous studies to assess the performance of agricultural support policies and the efficiency of agricultural activities. These comprehensive investigations have delved into the intricate effects of agricultural subsidies on various dimensions, including but not limited to crop yield, income generation, farm efficiency, and entrepreneurial behaviors (see Triyana et al. (2023), Amores A. and Conteras I. (2009)).

[6]Stochastic Frontier Analysis (SFA) is a parametric method that relies on numerous a priori assumptions about the production possibility set and data generation process. It assumes complete knowledge of these aspects, except for a finite set of unknown parameters. This assumption enables the incorporation of a stochastic relationship between inputs and outputs, accounting for deviations from the production frontier, which may arise from both inefficiencies and data noise.

[7]DEA is a non-parametric method used for assessing the relative efficiency of DMUs without making specific assumptions about the functional form of the production process or the distribution of efficiency scores. DEA is particularly useful when dealing with multiple inputs and outputs and allows for the identification of the most efficient units, which are considered as benchmarks. DEA does not involve estimating a stochastic component, thus it relies solely on observed data.

When considering the evaluation of policies such as CAP progress, there exist numerous diverse approaches that appear to be a perfect fit for this purpose. One such approach is the method known as Difference in Differences (DID), which is also commonly referred to as Dif-in-Difs. This particular type of analysis is primarily utilized in case studies, wherein researchers utilize two distinct groups, namely the treatment group and the control group, in order to measure the results before and after the implementation of the policy on these groups (see Pengfei et al. (2023)). Moreover, it is important to highlight another remarkable illustration of a classification methodology, known as the Cluster Analysis technique, which has proven to be highly effective in organizing various entities such as individuals, member states, and regions into well-defined clusters (see Svoboda et al. (2016)).

By grouping the regions specifically, it becomes evident that numerous regions will exhibit similar behaviors, while others will demonstrate distinct reactions to various forms of payment supports. Thus, to examine the economic socio-impact within a group of regions, it would prove advantageous to employ a Cluster Algorithm to group regions with similar reactions and subsequently investigate their divergent responses among groups. As seen in Shatolova et al (2022) on the clustering of Russia's industrially focused regions according to their economic specialization, policymakers and government officials can derive valuable insights to formulate effective industrial, innovation, and fiscal policies. Furthermore, the identification of clusters holds significant importance in gaining an understanding of the unique attributes and requirements of each region, thereby facilitating targeted policy interventions and resource allocation.

Regression analysis is another widely used in demographic research to analyze the relationship between population parameters and its constituent elements. It can be used to determine changes in process parameters in both temporal and spatial aspects (see Pylypenko I. and Malchykova D. (2022)). The utilization of the regression approach in small-area population forecasting has been steadily increasing in order to compute the associations between population change and the driving factors.

The Geographically Weighted Regression (GWR) method, is one of the many spatial regression methods which evaluates a local model of the variable or process by fitting a regression equation to every feature in the dataset in particular with geo-spatial data, presenting more sophisticated means of estimating these associations. However, it underperforms to the more conventional extrapolation projections[8]. The ratio-correlation method, on the other hand, is a widely employed regression-based approach that is utilized to estimate the total population of a specific region. One notable advantage of this method is its ability to generate meaningful measures of uncertainty surrounding the estimates it produces.(see Guangqing C. and Donghui W. (2017),Swanson D. and Tayman J. (2015).

[8]"Traditional Extrapolation Projections" refers to the established and commonly used methods of making predictions or estimations in demographic research, particularly related to population dynamics.

2.6 Closing Remarks

Summarizing the literature, it is apparent that agricultural subsidies in the EU have been found to have mixed effects on population change. While some studies suggest that subsidies increase agricultural labor productivity growth, leading to potential employment opportunities in the agricultural sector which translates to population growth (Helming J. and Tabeau A. (2018)), others indicate that the impact of subsidies on population change is unclear (Soliwoda M. (2016)). The specific types of subsidies also play a role in determining the outcome. Decoupled subsidies, such as Pillar I decoupled payments, have been found to increase agricultural labor productivity but not always, while coupled Pillar I subsidies have been shown to slow down productivity growth. The impact of Pillar II subsidies is mixed. Overall, the correlation between agricultural subsidies and population fluctuation is intricate, not only within Greece, and relies on a multitude of factors, encompassing the nature of the subsidy and its precise execution. However, the most crucial aspect lies in the significant disparities among rural areas. For example, some regions possess plenty of exploitable land for producers, while others face limitations due to the distinctive characteristics of their geographical location such as altitude, weather, distance to urban areas or public services etc.

There's a gap in this research area, existing literature isn't always easy to build upon, which is especially true for this specific research topic. In Greece, the rural population tends to be overlooked in today's society, so the changes in population are often only linked to the recent economic recession. However, there are actually many other reasons that have also played a part in these changes.

Future research in this domain could delve deeper into the factors that influence population change in Greece, beyond the economic recession. Exploring the social, cultural, and infrastructural dynamics that contribute to migration patterns and demographic shifts within rural and urban areas would provide a more holistic understanding. Additionally, comparative analyses between different regions, focusing on variations in agricultural practices, policy implementations, and local community dynamics, could uncover valuable insights. Lastly, investigating the effectiveness of targeted developmental policies aimed at mitigating depopulation in rural areas and promoting sustainable growth could contribute to informed policy-making units. The forthcoming chapter will feature a comprehensive examination of the data employed in this study, as well as a description the foundation behind the model selection and the approach taken to address the initial research inquiry, namely, the impact of agricultural subsidies on Greek rural population development.

Chapter 3

Methodology

3.1 Introduction

This section provides an essential explanation for the subsequent analysis and findings. By understanding the nature of the data and the techniques employed, an insight will be gained into the reliability and validity of the study's results. The section begins with an summary of the datasets utilized and their origins, followed by a discussion of the types and descriptions of variables. Furthermore, it outlines the data pre-processing steps undertaken to ensure the quality and integrity of the analysis. Also the chosen methodology is explained in detail, including the statistical methods and models employed, along with their underlying assumptions.

3.2 Research Design and Data Collection

Through institutional access, the Greek Payment Authority of Common Agricultural Policy, commonly referred to as OPEKEPE[1], serves as the primary source of the datasets pertinent to the producers' domain, referring to both farmers and breeders. The analysis involves two distinct datasets covering the years 2011 and 2019, each uniquely focused on specific attributes.

Another significant data source originates from the Hellenic Statistical Authority, commonly referred to as ELSTAT, which holds the responsibility of publishing statistical data for Greece. Data was acquired from ELSTAT's census reports for the years 2001, 2011 and 2021, specifically detailing population changes within each municipal community, and this information is publicly accessible. Additionally, the digital dimensions of the geographical boundaries of the Greek State were procured from ELSTAT, presented in the form of a shape-file.

[1]The primary mandate of OPEKEPE involves the oversight and control of benefits to recipients in accordance with both European and national legal frameworks. Annually, nearly 900,000 beneficiaries accrue benefits of approximately 3 billion EURO, sourced from community subsidies. These beneficiaries encompass a diverse spectrum, predominantly comprising farmers, farmer associations, export enterprises etc.

The design of this study incorporates a mixed-methods approach, encompassing both quantitative and qualitative methodologies. The first method aims to establish correlations among the variables of interest and, simultaneously, to obtain estimates for these correlations. The second method aims to comprehend the behavior of each community. Subsequently, it involves categorizing the communities into groups for the purpose of examining their collective behavior.

3.3 Variable Explanation

This part contains a brief overview of the data set that used for this research, presented to ensure clarity and coherence. Some of the variables play vital role so they need more attention and careful explanation. The average number of gas stations in a community is used as an indicator for the economic activity of this community. It is well known that gas stations are part of the retail sector, which is one of the indicators of local and regional economic activity and vitality. The output, sales, and employment of gas stations reflect the demand for motor fuel and other goods and services that they offer also the demand for motor oil or gas indicates a usage of agricultural machinery in this region.

Variable	**Type**	**Description**
KOD	Int	Identifier of each Community
MUNICIPALITY_ID	Int	Identifier of each Municipality
LEKTM	Chr	Name of Municipality
tot_pop	Int	Total Population (2001,2011,2021)
tot_growth	Int	Population Growth Rate 2001-2021
n_par	Int	Total Number of Producers (2011,2019)
n_young	Int	Total Number of Young Farmers
yng_subsidy	Int	Subsidies for Young Farmers
URBANITY	Int	Dummy Var. Based on Population
TERRAIN	Int	Dummy Var. Based on Altitude
ISLAND	Int	Dummy Var. (On island or not)
DENSITY	Int	Population Density (People/SqKm)
gas_station	Int	Average Number of Gas Stations
TELIKOVALUE	Int	Total Subsidy
growth_value	Int	Subsidies Growth Rate 2011-2019

Table 3.1: Type and Description of the Variables.

The population density is used as an indicator for the urbanity of a community. The Hellenic Statistic Authority identify a community as "*Urban*" if the population of this community surpasses the 2.000 residents and if it's not is identified as "*Rural or Agricultural*". Urban centers can achieve population density over 1.000 residents per Sq/Km so in order to distinct the urban communities from the urban center the variable density is used.

3.4 Descriptive Statistics

3.4.1 About 2011

Variable	N	Min	Max	Mean	SD
Producers	708,156	1	8,531	128	196.6
Payments	1,112,837	0	227,244.4	1,055.5	1,713.4
TOT. Subsidy	5,544	0	15,820,811	442,389.5	698,687.2

Table 3.2: Summary Statistics 2011 Subsidies

The table provides a summary of key statistics for various variables related to payments exclusively for 2011. For that year. The total number of producers that benefited through subsidies is 708.156, some communities had only 1 producer while others had 8.531 but on average the number of producers in a community was 128. In terms of payments, the total number of unique payments was 1.112.837 some producers received from 0 to 227.244,4 EURO with the average payment per producer to be around 1.055,5 EURO.

It is worth to note that out of 6.130 municipal communities 5.544 of them received at least one subsidy. The total amount of subsidy per community, on average, was around 442.389,5 EURO with the total subsidy to be in the range of 0 to 15.820.811 EURO.

In 2011 the government established 34 different schemes through the common agricultural policy to support farmers across the state with total spending to be around 2.452.607.298 EURO. The biggest support went through "*coupled payment scheme*[2]" with the total of 21.34%. Furthermore, the government extended support to those adversely affected by various unusual weather phenomena[3], allocating 16.75% of the total support for this purpose. Notably, 13.46% of the total support was allocated for the "Additional Support of Goat Probe," a relatively higher percentage compared to other additional supports such as Hard Wheat, Cotton, or Olive cultivation, which collectively received lower additional support.

[2]The Coupled Payment Scheme is designed to provide essential support to every farmer in Greece who possesses aid rights. This program plays a crucial role in assisting not only larger agricultural enterprises but also smaller-sized farms that may encounter challenges in meeting their financial obligations. The financial aid provided through this scheme serves as a lifeline for these smaller farms, helping them overcome potential difficulties in covering operational costs and sustaining their agricultural activities.

[3]This includes extreme temperatures, drought, floods, storms, frost, hailstorms, and pest outbreaks. Extreme temperatures, whether excessively high or low, can affect crop growth and yield. Drought involves prolonged periods of abnormally low precipitation, leading to water shortages for crops. Floods result from excessive rainfall or sudden water overflow, causing damage to crops and disrupting agricultural activities. Storms, such as hurricanes or tornadoes, can inflict significant harm on crops and infrastructure. Unexpected frost events and sudden hailstorms can harm sensitive crops, while severe pest outbreaks can lead to substantial crop losses.

3.4.2 About 2019

Variable	**N**	**Mean**	**SD**	**Min**	**Max**
Payments	2,814,226	630.5	916.5	-11,448.51	119,828.7
Producers	1,982,788	98.4	159.2	1	7,490
TOT. Subsidy	5,852	266,595.3	435,451.7	−0.01	9,944,012

Table 3.3: Summary Statistics 2019 Subsidies

The table above provides a comprehensive overview for the distribution of total subsidies across each municipality in the year 2019, shedding light on critical characteristics of these supports. In 2019, a total of 2,814,226 payments were made to 1,982,788 farmers across 5,852 Municipal Communities and each beneficiary was approved for 1.5 subsidies this year. On average, each producer received approximately 630.50 EURO with a substantial standard deviation of 916.50 EURO, indicating significant variability. The payment range varied from -11,448.51 EURO to 119,828.70 EURO. Additionally, it's worth noting that, on average, each Municipal Community had approximately 98 producers, with a standard deviation of 159.2. Some communities had as few as one producer, while others had as many as 7,490. Lastly, it's essential to consider the total payments across all subsidy types received by farmers. On average, each community received 266,595.30 EURO. Notably, the sum of all subsidies for some communities was as low as -0.01 EURO, while for others, it reached 9,944,012 EURO with the total amount of support to be 1.560.115.587 EURO which is far lower compered to 2011.

#	**Aid Scheme**	**Frequency**
1	SUPPORT FOR AGRICULTURAL PRACTICES BENEFITTING CLIMATE AND ENVIRONMENT (GREENING)	16.84
2	BASIC SUPPORT SCHEME	16.84
3	YOUNG FARMERS	15.21
4	LINKED SUPPORT FOR THE CULTIVATION OF PROTEIN-RICH FEED GRAINS	9.53
5	LINKED SUPPORT FOR THE CULTIVATION OF FRUITS WITH SHELL	8.89
6	Aggregation	8.49
7	LINKED SUPPORT FOR THE CULTIVATION OF PROTEIN-RICH FEED PSYCHANTHOS	7.21
8	STATE SUPPORT OF EQUAL IMPORTANCE	4.97
9	LINKED SUPPORT FOR THE CULTIVATION OF EDIBLE LEGUMES	4.48
10	LINKED SUPPORT FOR THE CULTIVATION OF HARD WHEAT	4.15
11	LINKED SUPPORT FOR APPLE CULTIVATION	3.07
12	LINKED SUPPORT FOR THE CULTIVATION OF SUGAR BEETS	0.33

Table 3.4: Frequency and Percentage per Type of Subsidy

3.4.3 About Subsidies Across Terrain

Communities can fall into various classes, with one classification criterion being the terrain (altitude) which is located. Depending on these factors, a community may be categorized as Lowland, Semi-Mountainous, or Mountainous. The following two tables illustrate how subsidies are distributed among different terrain classifications, providing insights into the subsidy distribution patterns.

Table (3.5) captures the subsidy growth rate across urban and rural communities for every factor in the variable Terrain. Firstly, rural communities faced bigger declines in subsidy growth rate compared to urban. Notably, rural areas in Lowland terrain exhibit the highest mean subsidy growth (-34.2%), while urban areas in Semi-Mountainous terrain show the lowest mean subsidy growth (-27.7%).

URBANITY	**TERRAIN**	**Variable**	**n**	**Mean**	**SD**
Urban	Lowland	Subsidy Growth	240	-30.6	18.2
Rural	Lowland	Subsidy Growth	1876	-34.2	16.4
Urban	Semi-Mountainous	Subsidy Growth	61	-27.7	19.3
Rural	Semi-Mountainous	Subsidy Growth	1321	-31.8	17.1
Urban	Mountainous	Subsidy Growth	33	-30.0	16.3
Rural	Mountainous	Subsidy Growth	1804	-34.1	19.6

Table 3.5: Summary Statistics for Total Subsidy Growth (%) by Urbanity and Terrain

From a different standpoint, the following table offers a short summary of the subsidy allocation in both 2011 and 2019, categorized by various terrains. While it is obvious that there has been a reduction in government funding towards agriculture (as displayed in the preceding table) but, a significant observation is that mountainous regions have received the least support, getting nearly half as much as the lowland regions in both year

TERRAIN	**Variable**	**n**	**Mean**	**SD**
Lowland	TOT. Subsidy 2011	1847	278,886	227,937
Lowland	TOT. Subsidy 2019	1847	189,331	156,517
Semi-Mountainous	TOT. Subsidy 2011	1375	242,997	213,277
Semi-Mountainous	TOT. Subsidy 2019	1375	161,297	145,135
Mountainous	TOT. Subsidy 2011	2064	149,517	175,088
Mountainous	TOT. Subsidy 2019	2064	103,640	126,863

Table 3.6: Summary Statistics for Total Subsidies (2011 and 2019) by TERRAIN.

3.4.4 About Administrative Units

According to the most recent administrative changes, there are a total of 326 administrative units, each comprising 6,132 local communities. Consequently, the Greek government has subdivided the state into numerous small governing bodies. Thus, it is anticipated that an increase in the number of *Urban* regions will occur where the elevation is relatively low, while a rise in *Rural* areas will be observed as the altitude increases. This hypothesis can be validated by examining the subsequent graphs. Initially, a breakdown of the different types of terrain is depicted as a percentage, followed by a map graph illustrating the altitude distribution among the municipalities.

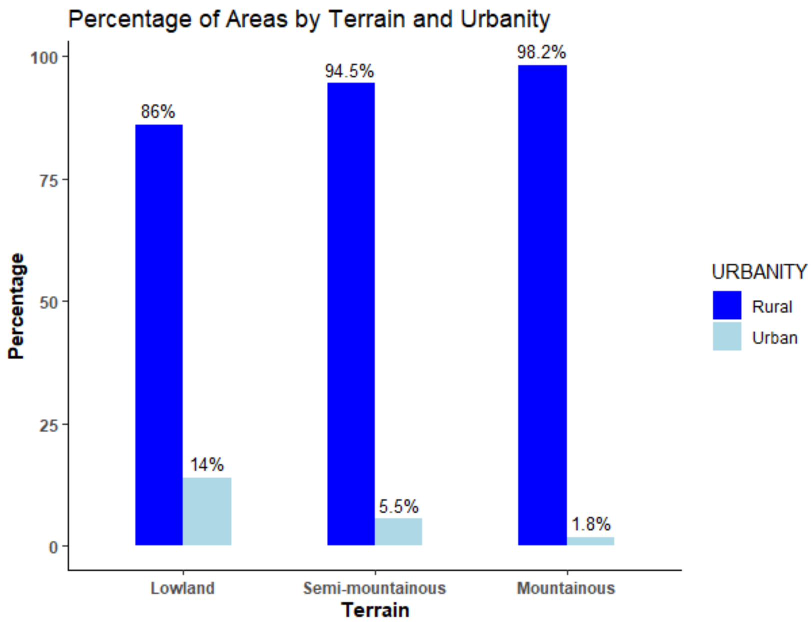

Figure 3.1: Distribution of urban and rural areas across different terrain.

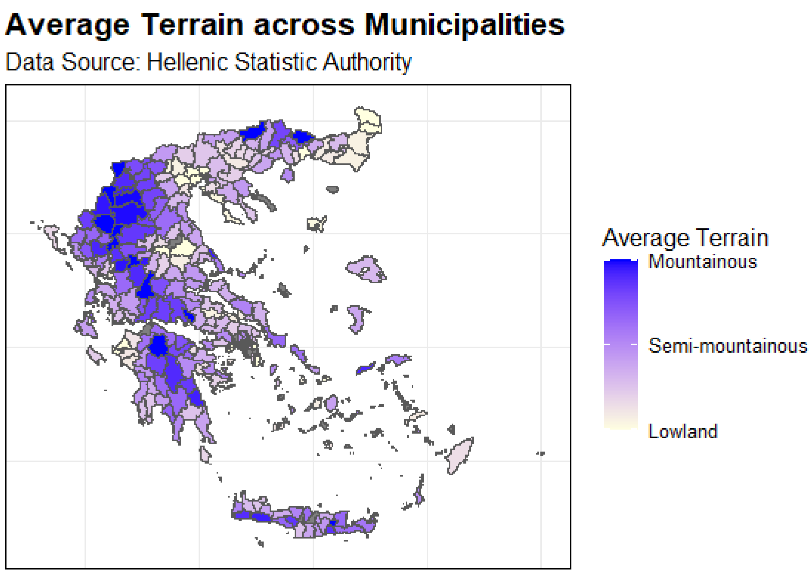

Figure 3.2: Spatial Distribution of Average Terrain across Municipalities.

Municipal communities can be characterized with various criteria, for the purpose of this study only a few of those will be included to ensure the relevance of the inputs and the estimated output. First of all, it is important to understand the terrain on which municipalities are located. As seen in previous section, Greece is build upon mountains and landscapes and this can very evident through the data that ELSTAT provides. The regions in Greece can be separated into two categories based on population, first the areas with population more than 2.000 are called *"Urban"* while areas with less than 2.000 are called *"Rural"* and second based on the terrain we have the *"Lowland"*, *"Semi-mountainous"* and *"Mountainous"*.

The following graph explains two pivotal constituents of the Hellenic nation. On a mean scale, the disparity amid urban and rural regions is incredibly substantial, while at the same time, it demonstrates, with an elevation increase, the mean populace diminishes in both urban and rural localities. The terrain in Greece is a variable that explains many of the things that can be observed but as stated in Terkenli T. (2004) the research on this field has seen very limited progress[4].

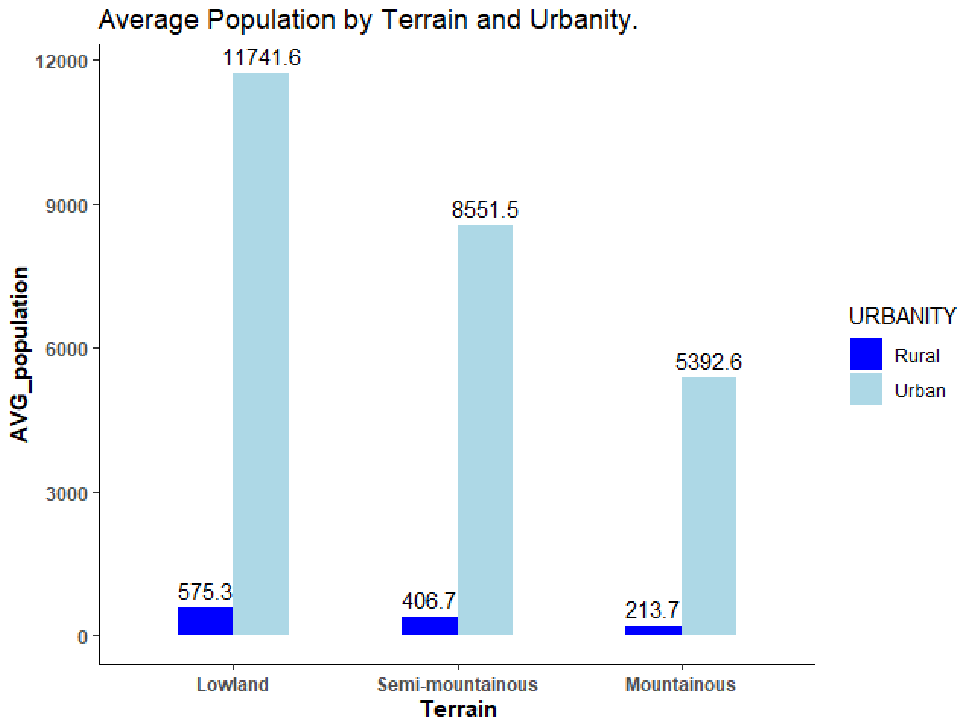

Figure 3.3: Population of urban and rural areas across different terrain (community level).

[4]There are few researches in this domain, in majority of instances scientists explore the connection between the Greek morphology and factors surrounding the alteration of weather patterns, sustainable power, biodiversity etc. (see Katsoulakos N. and Kaliampakos D. (2016), Panagiotopoulos G. and Kaliampakos D. (2019))

The latest census reports from ELSTAT made it clear that a demographic problem across Greece is present. The resident population of 2021 is reduced by 3.1%, and a declining population can cause labor shortages, impacting labor-dependent sectors like agriculture and potentially increasing labor costs. It also reduces tax revenue for local governments, making it challenging to maintain infrastructure. This population decline can hinder economic growth, affecting businesses, jobs, and overall prosperity in the region. The following graphs are spatial visualizations of the average population growth (in %) and the average population density across municipalities.

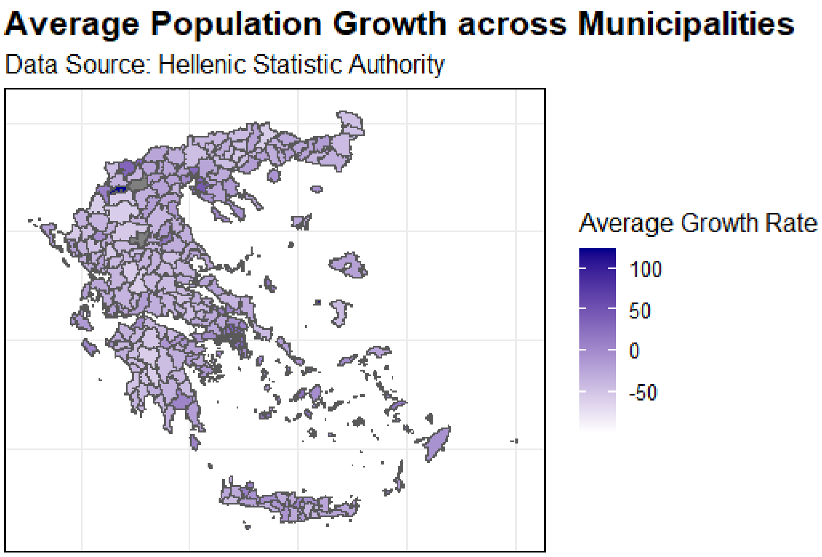

Figure 3.4: Spatial Distribution of Average Population Growth across Municipalities (%).

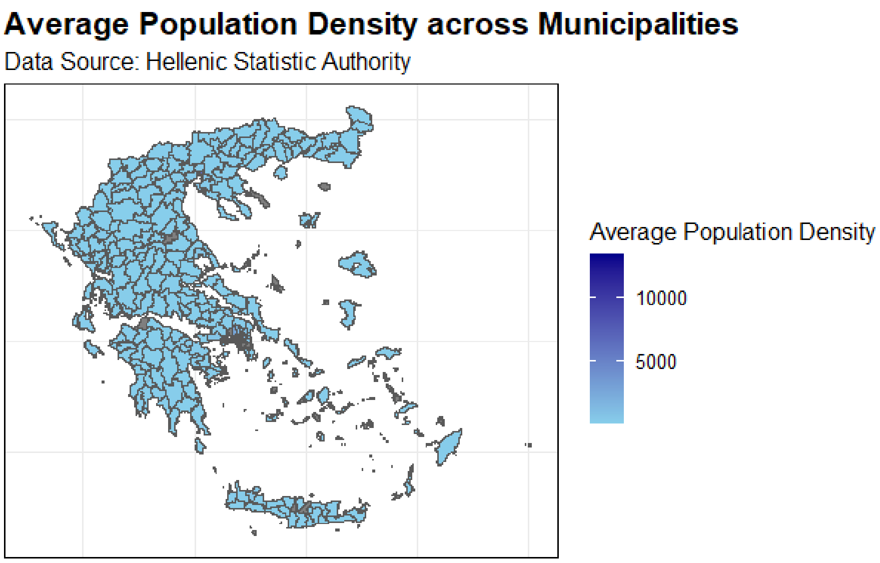

Figure 3.5: Spatial Distribution of Average Population Density across Municipalities.

A noteworthy initiative by the European Union has been its strategic focus on cultivating a new generation of farmers, which serves to boost the agricultural population not only across Europe but also in the context of Greece. This worthy endeavor has yielded an additional benefit, a reduction in the widespread issue of the aging demographic within farming communities. The following figure provides a visual representation of the cumulative count of young farmers at the municipal level for the year 2019, it is clear which regions were taken advantage of current situation.

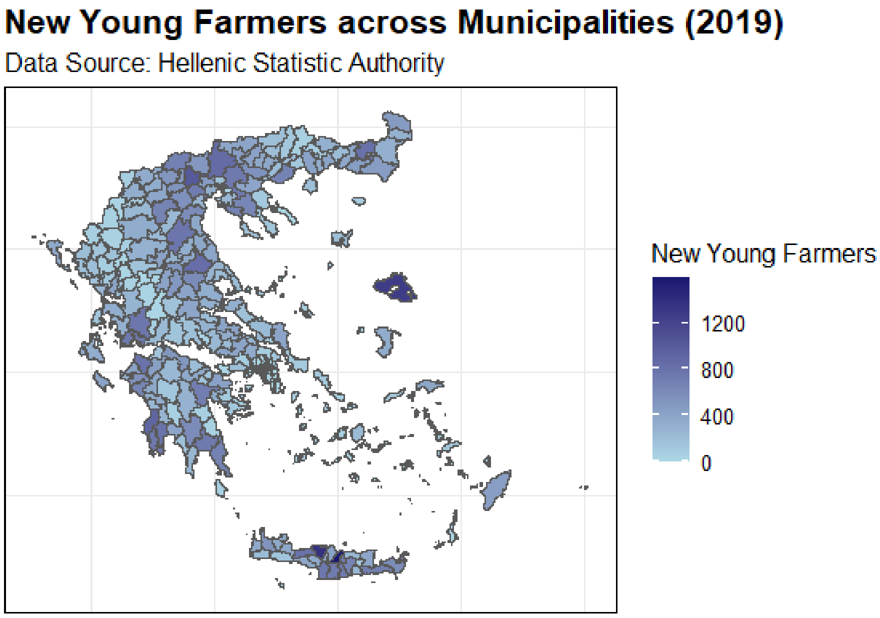

Figure 3.6: Spatial Distribution of New Farmers across Municipalities.

The strategy of New Farmers[5] offers a potential solution to combat rural depopulation. While initially drawing young individuals to the agricultural sector is relatively straightforward, the real challenge lies in retaining and ensuring their sustainable livelihoods within this profession.

The New Young Farmers scheme policy also aims to improve the economic activity of rural regions. Recent study revealed significant positive impacts on regional output and employment, with income generation showing positive effects but to a lesser extent. The Scheme's contributions are estimated to result in indirect job creation in rural areas, amounting to 20% of the direct employment represented by the number of new entrants. Summing up, the Young Farmers Scheme emerges as a valuable tool for policymakers, contributing to the support the preservation of social and economic cohesion, the stimulation of regional output, the transformation of the agricultural population, and the enhancement of rural employment (see Gkatsikos et al. (2022)).

[5]In the study of Chatzitheodoridis F. and Kontogeorgos A. (2020) undertaken in Greece revealed that a significant majority of newcomers expressed a considerable degree of satisfaction regarding their choice to engage in agriculture under the "New Entrants Policy" initiative. More specifically, new farmers who exhibited a heightened environmental consciousness and implemented field practices geared toward environmental protection reported notably elevated levels of contentment with their decision to pursue a career in agriculture.

3.5 Software Used

The research is built upon the R (version 4.3.1) programming language and is facilitated through RStudio. The selection of this programming language was made following a comprehensive assessment of its capabilities, as well as the unique features offered by various packages. This decision was not solely driven by its analytical functions, but also by its suitability for creating visually appealing presentations.

3.6 Data Preparation

To address the presence of outliers in the dataset, a robust method was employed involving the computation of the interquartile range (IQR). The first quartile (Q1) and third quartile (Q3) of the Population and Subsidy growth rates were determined, and the IQR was calculated as the difference between Q3 and Q1. Data points beyond a specified threshold, more specific 1.5 times the IQR above the third quartile or below the first quartile, were identified as outliers. This systematic approach allowed for the identification and subsequent removal of outliers from the dataset, contributing to the robustness of the subsequent analyses.

3.7 Quantitative Analysis

3.7.1 Linear Regression

The techniques that have been employed for the purpose of conducting a quantitative analysis are simple and multiple linear regression estimated using the Ordinary Least Squares. The implementation of these types of analyses has the potential to generate a representation of the extent to which various factors influence the population change. These methods allow an examination of the connection between numerous independent variables and a dependent variable (see Lafazani P. and Lagarias A. (2016), Graves C. (1965), Rachman et al. (2021)).

While various methods are available for exploratory analysis, simple and multiple linear regression are frequently preferred for several compelling reasons. They are characterized by their efficiency, allowing for the rapid estimation of coefficients, standard errors, confidence intervals, and other statistical parameters, enabling hypothesis testing and the assessment of the significance of relationships. Furthermore, linear regression, in particular, is favored as an ideal choice for establishing a baseline model due to its simplicity. Finally, the estimation using the Ordinary Least Squares method, provides an approximation closest to the actual outcome (see Verbeek M. (2017)). In summary, these quantitative analysis methods are used in order to gain a correlational understanding rather than to investigate causality.

3.7.2 Simple Linear Regression

Starting by specifying the baseline model on which later on the necessary changes will be applied. So, the following model uses *Population Growth Rate* (%) from 2001 to 2021 as the dependent variable (Y). Here, β signifies the estimates for the *Intercept*, and the coefficient of the *Total Subsidy Growth Rate* (%), X is the Subsidy growth while *e* denotes the standard error term for all the municipal communities (N).

$$y_i = \beta_0 + \beta_1 \cdot X_i + e_i \quad , \quad i = 1, \ldots, N \tag{3.1}$$

It is important to verify that this model follows the assumptions of the linear regression. First, the correlation between depended and independent variable is linear. Next, the expected value of the disturbance term is equals to 0 and does not follow a trend, this can be proved through a plot of residuals against fitted values.

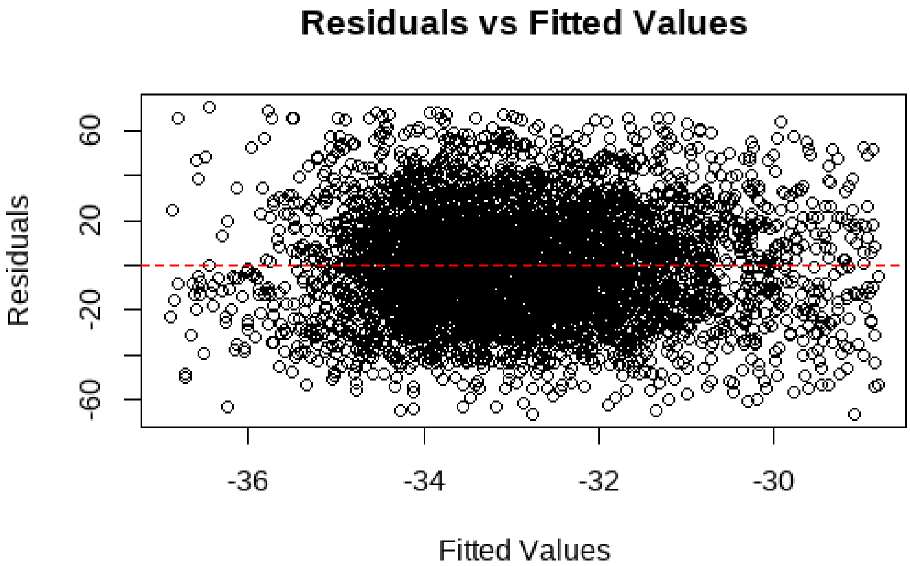

Figure 3.7: Residual Plot of Baseline model.

It is clear that the residuals do not follow a trend or pattern and they're randomly scattered around the horizontal line (which equals to 0), this suggests that the assumption of the expected value of the disturbance term is equals to 0 is not violated. The previous figure confirms another assumption – the assumption of homoscedasticity. The spread of residuals does not systematically increase or decrease with fitted values. This suggests that the assumption is not violated. The next figure displays the distribution of the residuals which follow the normal distribution with $e_i \sim \mathcal{N}(0, \sigma^2)$.

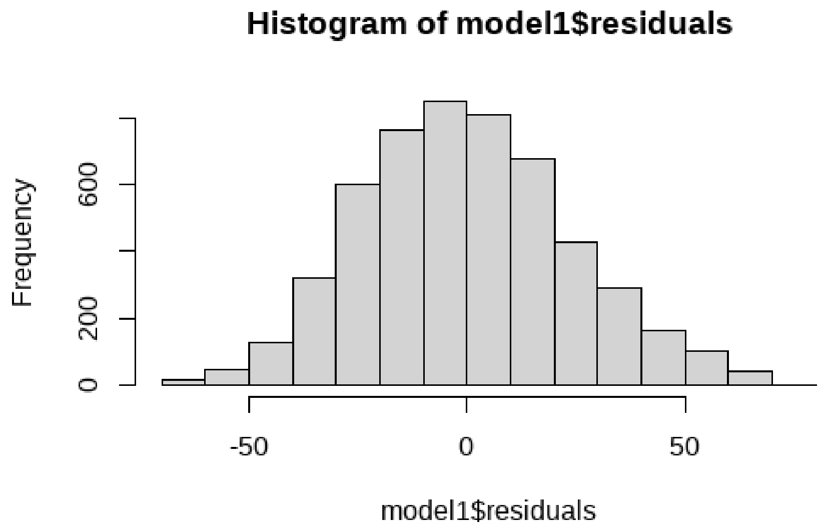

Figure 3.8: The distribution of the residuals.

The last assumption that is needed to be discussed before the estimation is the assumption of auto-correlation between residuals. In the case of this study, the data are cross-sectional and non ordered thus, the auto-correlation assumption is not violated.

3.7.3 Multiple Linear Regression

The multiple linear regression builds upon the previous model, allowing for comparisons with models merging additional independent variables. Two new variables, "gas stations" and "island," are introduced. The average number of gas stations per community serves as a proxy variable for economic activity, reflecting higher activity in areas with more gas stations. The "island" dummy variable is included to account for the influence of community location on population growth, distinguishing between island and non-island communities. This extension enables a more comprehensive analysis of factors affecting population growth across diverse communities.

3.7.4 Variable Selection

For the variable selection, a stepwise variable selection process was applied. The forward selection stepwise procedure was initiated with an initial model that included predictor variables such as Urbanity, Terrain, Population Density, Gas Stations, Island, Total and Average Subsidy Growth Rate. The results indicated that no variable was found to be statistically significant for removal, as evidenced by the lack of improvement in the AIC value. However, the backward elimination process identify the average subsidy growth as a variable that significantly improved the model fit based on the AIC criterion.

Thus, the suggested multiple linear regression model, obtained from both stepwise procedures[6], includes the intercept and the following coefficients: Urbanity (-14.97), Terrain (-7.79), Density (0.01), Gas Stations (2.07), Island (13.98), and Total Subsidy Growth (0.06).

The next table presents an overview of the independent variables utilized in both Model 2 and Model 3 as well as the baseline model. Although each model specification incorporates distinct independent variables, the dependent variable remains constant, specifically, the population growth.

Independent Variable	**Models**
Total Growth of Subsidies	Baseline, Model 3
Growth Rate of Average Subsidies	Model 2
Urbanity	Model 3
Terrain	Model 3
Population Density	Model 3
Average Gas Stations	Model 3
Island	Model 3

Table 3.7: Independent Variables in Linear Regression Models

The subsequent equations (4.2) and (4.3) illustrate Model 2 and Model 3, respectively.

$$y_k = \beta_0 + \beta_1 \cdot X_k + e_k \quad , \quad k = 1, \ldots, N \tag{3.2}$$

$$y_j = \beta_0 + \beta_1 \cdot X_{1j} + \cdots + \beta_7 \cdot X_{6j} + e_j \quad , \quad j = 1, \ldots, N \tag{3.3}$$

Both models are linear, the difference is that in the models (2) and (3) the mean residual will asses the non violation of auto-correlation assumption which is calculated at -1.120821e-15 for model (3) which suggests that, on average, the residuals center around zero. Similarly, the mean residual for the model (2) is calculated at 7.369307e-15 also very close to zero indicating that the model's expected value for residuals is near zero.

The normality for both models residuals can be proved through a Student's t-Test, the following table suggests that there is no significant evidence to reject the null hypothesis and that the true mean of the residuals is equal to zero. This supports the assumption of a mean-centered. Lastly, through Goldfeld-Quandt test the homoscedastisity is addressed, in the case of both models the null hypothesis is failed to be rejected with p-value 0.7349 and 0.9655 respectively suggesting that the variance of residuals is constant so, the conclusion for both models is $e_i \sim \mathcal{N}(0, \sigma^2)$.

[6]The stepAIC function is used from the MASS library of R which streamlines the process of stepwise linear regression model selection. By employing the Akaike Information Criterion (AIC), it systematically adds or removes predictors to enhance model fit, aiming for a balance between explanatory power and simplicity. The function iteratively refines the model until further adjustments cease to decrease the AIC.

Model	T-Statistic	Degrees of Freedom	P-Value	95% Confidence Interval
Model 2	9.22×10^{-15}	5075	1	(-1.57, 1.57)
Model 3	1.16×10^{-14}	4705	1	(-0.54, 0.54)

Table 3.8: Student's t-Test Results for Residuals

As seen in the baseline model, the usage of cross sectional, non ordered data concludes to the non violation of the auto-correlation assumption between residuals. That is also the case for both models (2) and (3) so there is no violation of the classic linear regression model assumptions.

To investigate the circumstances under which subsidies influence population change, the previous models specifically target different community groups. The examination covers the terrain of the community, comparison between urban and rural communities and additionally, considers the behavior of island communities.

3.8 Qualitative Analysis

3.8.1 Cluster Analysis

As observed in former sections, There are limited similarities found among various municipalities. Each and every locality possesses something distinct that plays a pivotal role in shaping its behavior. Even neighboring administrative units that belong to the *"Rural"* category can exhibit markedly dissimilar characteristics. Therefore, in order to comprehend the cause behind the impact of agricultural subsidies on population dynamics, a classification is conducted. This classification not only helps to identify similarities in behavior, but also similarities in outcomes following to the provision of subsidies.

The chosen classification technique in this study is the "K-Means Algorithm," a commonly utilized method that segregates observations into separate groups, also known as clusters, based on their intrinsic traits. This approach holds significant importance for this examination as each community varies from the rest, and for a policy valuation, it is crucial to pinpoint the factors that contribute to the effectiveness of the policy. The numbers of clusters is identified through *"Elbow Method"* and as seen in Bholowalia P. and Kumar A. (2014) The technique is a methodology that examines the proportion of variance explained as a consequence of the quantity of clusters. The basis of this methodology lies on the number of cluster that can explain the data the most and the count of an additional cluster does not significantly enhance the modeling of the data. The proportion of variance clarified by the clusters is graphed in relation to the number of clusters with and "Elbow" shape.

Both K-Means algorithm and the Elbow method are selected based on the notable advantages for this study. K-Means offers simplicity, interpretability, scalability, and adaptability, making it applicable to the various data types that will be used. The Elbow method complements K-Means by aiding in the selection of the optimal number of clusters, enhancing the algorithm's effectiveness so this is a strong combination. The main disadvantages as seen in Sonagara D. and Badheka S. (2014) are the difficulty on outlier identification and on the inability to handle non-globular data of different sizes and densities.

3.8.2 Community Efficiency Index

It is essential to understand and distinguish which communities can be more influenced from the subsidies and also categorize them based on this influence. For this purpose, a metric is employed to measure the efficiency of subsidies. The following equation represents the 'Community Efficiency Index' (CEI). In economic theory the 'Price elasticity of demand' captures the impact of a small price change to the total demand, following this concept the CEI captures this "elasticity" of the subsidies to the population change. A relative positive index implies that the community is experiencing growth at a rate higher than the increase in subsidies, thus, a small change in subsidy growth causes a bigger growth in population change.

Similarly, a low index suggests that the community is not adequately responding to the growth of subsidies. Therefore, the CEI serves as a measure for evaluating a community's efficiency in relation to the financial support it receives. This aligns with the concept that communities are considered more efficient when they undergo significant population growth relative to the increase in agricultural subsidies.

The equation (3.4) consists of two elements, the population growth rate divided by the subsidy growth rate in absolute values.

$$CEI = \left| \frac{\text{Population Growth Rate}}{\text{Subsidy Growth Rate}} \right| \tag{3.4}$$

In addition to assessing efficiency, this analysis incorporates a new different approach. Each community is compared with its neighboring community that shares the maximum border length. This particular comparative analysis represents an additional attempt to derive qualitative outcomes, aiming to comprehend the efficacy of agricultural support and assess the overarching policy if the LEADER program. To achieve the optimal outcome, a careful examination is conducted for each group, comparing communities that surpassed their neighbors with those that did not, within the same area group using dummy variables such as terrain, island and urbanity.

It is important to note that, in pairwise comparisons between neighboring communities, the term "more efficient" refers to the community that can obtain greater benefits from the subsidies with regard to the population. To mitigate the potential for biased output, the resulting index is further refined by applying a filter that removes outliers using the Interquartile Range (IQR) method, enhancing the robustness of the interpretation. The following section digs into the groundwork of this study, the results, focusing on the inspection and presentation of the outcomes.

Chapter 4

Results

4.1 Simple Linear Regression

For the estimation, is chosen to be used the *Ordinary List Squares* estimator (OLS). The following table presents the results of the single linear regression. Specifically, the growth rate of subsidies has a statistically significant positive effect on the population growth rate (Estimate = 0.077, $p < 0.01$). The constant term represents the estimated population growth rate when all independent variables are zero and it is statistically significant with a negative effect (Estimate = -30.335, $p < 0.01$). The limited R-squared value (0.003) suggests a modest proportion of variance explained, this was expected because there are many reasons for someone to leave it's home town. The residual standard error in this model signifies the average magnitude of the residuals, which is indicating that the model might not capture all the underlying patterns in the data. Lastly, the F-statistic (17.548), coupled with a p-value below 0.01, confirms the overall model significance.

	Coefficient
$\hat{\beta}_1$	0.077^{***}
	(0.018)
$\hat{\beta}_0$	-30.335^{***}
	(0.698)
Obs	5,216
R^2	0.003
Adjusted R^2	0.003
Residual SE	23.855 (df = 5214)
F Statistic	17.548^{***} (df = 1; 5214)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 4.1: Results of Simple Linear Regression

The next figure displays the correlation between the same variables which is followed by Pearson's correlation coefficient which equals to 0.06, meaning that there is a very weak, statistical significant, positive correlation between the population growth rate and the subsidy growth rate. Communities with high subsidy rate tent to have bigger population growth.

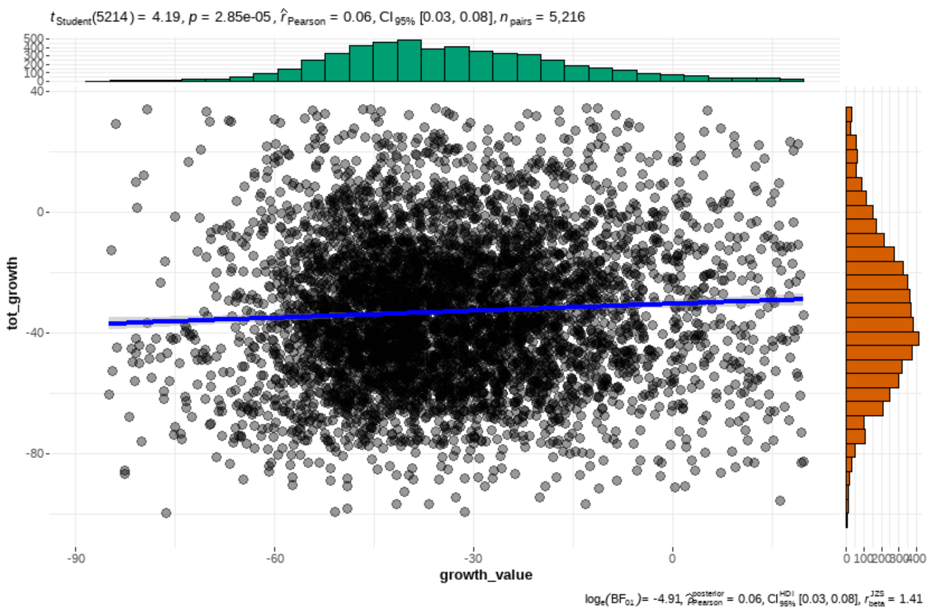

Figure 4.1: Scatter plot of Population and Subsidy Growth Rates.

4.2 Multiple Linear Regression

The following table displays the results after the regression using the OLS estimator for every model and presents some very important insights. To start with by comparing baseline model (1) with model (2), the baseline model includes only the total growth rate of subsidies as independent variable while model (2) replaces it with the mean subsidy growth rate from 2011 to 2019. The baseline model captures a positive correlation between the total subsidy growth rate and the population growth rate. In contrast, model (2) reveals an inverse relationship, signifying that an increase in the total subsidy across a community positively influences the population growth rate, while an increase in the mean subsidy across a community exerts a negative impact on population growth.

On the other hand, model (3) captures a bigger picture of the variation of the population growth. For example, terrain has a negative impact on the population change, as communities with higher altitude tend to have lower growth rates. However, the economic activity of a community has a positive impact on the population change, which can be observed by the average number of gas stations.

	Dependent Variable: Population Growth		
	Model (1)	Model (2)	Model (3)
URBANITY			-14.972^{***}
			(1.528)
TERRAIN			$\mathbf{-7.792}^{***}$
			(0.337)
DENSITY			0.006^{***}
			(0.001)
Gas Stations			$\mathbf{2.069}^{***}$
			(0.210)
ISLAND			13.975^{***}
			(0.666)
Subsidy Growth	$\mathbf{0.077}^{***}$		0.063^{***}
	(0.018)		(0.016)
Mean Subsidy Growth		$\mathbf{-0.06}^{**}$	
		(0.021)	
Constant	-30.335^{***}	-37.109^{***}	$\mathbf{8.45}^{***}$
	(0.698)	(1.081)	(3.153)
Obs	5,216	5,052	5,177
R^2	0.003	0.002	0.273
Adjusted R^2	0.003	0.001	0.272
Residual SE	23.855	21.943	20.244
F Statistic	17.548^{***}	8.080^{***}	323.759^{***}
Note:			$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 4.2: Regression Analysis Results

Each variable incorporated into the models has demonstrated statistical significance based on the OLS estimator at the a = 0.05 so through hypothesis testing it is evident that with 95% confidence non of the variable included in the models will have no impact on the dependent variable because no variable includes zero between lower and upper bound which is presented in the next table.

The first two models display a negative constant term while model (3) the opposite, meaning that,even when all predictors in your model have zero values, the predicted value of the population growth is positive. While the hypothesis testing indicates that population growth will have positive growth rate if no action is taken, there are many more factors that influence the population change.

Model	Variable	95% Confidence Interval	
		Lower Bound	Upper Bound
Model 1	**Intercept**	**-31.70**	**-28.97**
	TOT. Subsidy Growth	0.04	0.11
Model 2	**Intercept**	**-43.81**	**-32.77**
	AVG. Subsidy Growth	-0.29	-0.07
Model 3	**Intercept**	**2.089**	**14.66**
	Urbanity	-17.96	-11.97
	Terrain	-8.452	-7.125
	Density	0.003	0.008
	Gas Stations	1.65	2.47
	Island	12.64	15.35
	TOT. Subsidy Growth	0.03	0.09

Table 4.3: 95% Confidence Intervals for Regression Coefficients

Finally, the following figure illustrates the correlation coefficient of the Winsorized Correlation, a method that addresses extreme values by adjusting the tail values to a specified percentile. While all variables appear to have a positive impact, it is noteworthy that terrain exhibits a negative effect on population growth. Further details on this influence are explained in subsequent sections.

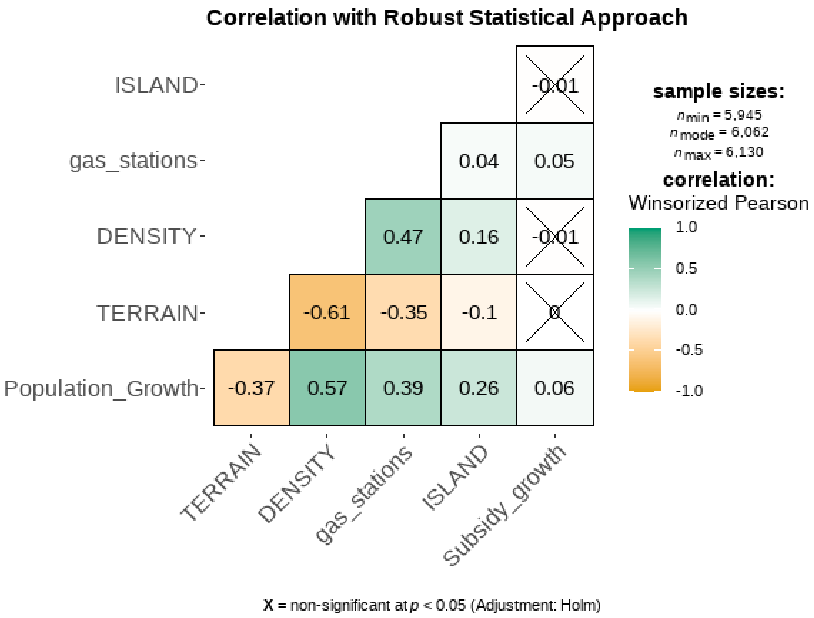

Figure 4.2: Winsorized Pearson's Correlation Coefficient.

4.2.1 Examination based on Terrain

The presence of instrumental variables such as Urbanity and Terrain or Island can be a very useful method to isolate only the communities with specific characteristics and investigate more focused the influence of subsidies to the population growth. The next logical question that arose is to investigate this influence based on the terrain of each community. The next table provides the coefficients of OLS estimator for the various terrains. In each scenario, none of the following models violate any of the assumptions of classical linear model.

Many unique findings were associated with this approach. The urbanity, which captures whether a community is urban or rural, has a significant impact on population growth. Additionally, the density of the region seems to play a vital role in population growth, indicating that if a community becomes more dense, it will contribute to positive population growth. A striking discovery is the situation with mountainous regions. Population growth appears to be unclear for lowland or semi-mountainous areas, but mountainous communities were found to have a statistically significant negative constant term. This suggests that these communities will experience a population decrease if the other characteristics remain constant. Economic activity positively influences population growth, and the impact is almost 3.5 times greater in mountainous areas.

	Dependent variable:		
	Population Growth		
Terrain	(**Lowland**)	(**Semi-Mountainous**)	(**Mountainous**)
URBANITY	-14.567^{***}	-14.360^{***}	-9.538^{**}
	(1.881)	(3.194)	(4.286)
DENSITY	0.006^{***}	0.029^{***}	0.173^{***}
	(0.001)	(0.008)	(0.024)
Gas Stations	1.563^{***}	1.792^{***}	5.361^{***}
	(0.250)	(0.488)	(1.051)
ISLAND	15.502^{***}	13.526^{***}	10.130^{***}
	(1.090)	(1.098)	(1.354)
Subsidy Growth	$\mathbf{0.061}^{**}$	**0.032**	$\mathbf{0.067}^{***}$
	(0.027)	(0.031)	(0.025)
Constant	−0.282	−8.937	-28.347^{***}
	(3.832)	(6.455)	(8.720)
Observations	2,020	1,345	1,812
R^2	0.208	0.190	0.144
Adjusted R^2	0.206	0.187	0.141
Residual Std. Error	20.146 (df = 2014)	19.297 (df = 1339)	20.320 (df = 1806)
F Statistic	105.576^{***} (df = 5; 2014)	62.938^{***} (df = 5; 1339)	60.641^{***} (df = 5; 1806)
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 4.4: OLS Estimation Based on the Dummy Variable Terrain.

4.2.2 Examination of Island Communities

Following the previous results the question that arose is find the influence of the subsidies to based on the terrain variables but only for island communities. In previous section, the presence of the island communities was addressed, it is more likely that communities located on an island to have different reaction to the subsidies comparing it a non island community. Due to the fact that almost 96% of the communities fall into the *Rural* category, meaning that they have population less 2.000 the urban communities will not be accounted and the next models includes only Rural communities. The next table provides the coefficients of OLS estimator for the various terrains only for Rural and Island communities.

	Dependent variable: Population Growth		
Terrain	**(Lowland)**	**(Semi-Mountainous)**	**(Mountainous)**
DENSITY	0.118***	0.096***	0.456***
	(0.013)	(0.021)	(0.093)
Gas Stations	**−0.600**	5.519***	**5.685**
	(1.002)	(1.365)	(3.555)
Subsidy Growth	**0.102**	**0.153***	**0.176***
	(0.065)	(0.050)	(0.058)
Constant	−20.123***	−23.816***	**−39.119***
	(2.783)	(1.969)	(2.559)
Obsrvations	402	490	265
R^2	0.164	0.089	0.152
Adjusted R^2	0.158	0.084	0.142
Residual SE	21.845 (df = 398)	20.007 (df = 486)	19.835 (df = 261)
F Statistic	26.088*** (df = 3; 398)	15.884*** (df = 3; 486)	15.598*** (df = 3; 261)
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 4.5: OLS Estimation Based on the Dummy Variable Terrain only for Island Communities

This approach raised very unexpected results. Although the observations seem to be normally distributed there is a positive skewness (the most variables are located to the left or most of the communities fall into the Lowland category). Once again the constant term in the mountainous areas is almost 2 times bigger compared to the other groups, increasing the population density will have the biggest impact on these areas while increasing subsidies will also result to a positive impact on population development.

The result that was unexpected was the fact that the economic activity found to have none statistical significant impact on the lowland and mountainous regions, lowland population also discovered to have negative influence from the number of gas stations but this coefficient is not statistical significant thus, the real impact might be actually positive. Comparing the three models, the lowland and mountainous models seem to explain better the variance of the dependent variable with adjusted R squared 0.15 and 0.142 respectively.

4.3 Cluster Analysis

The chosen method to classify the municipal communities into groups is the K-Means algorithm. For the purpose of this study, this unsupervised[1] methodology not only provides valuable information but also fits perfect from applicability's perspective while can handle large datasets with large amount of data points. This algorithm is sensitive to outliers thus, as done for the linear regression, an identical method was employed which computes the interquartile range (IQR) and only the observations within that range are used, the main difference with the previous data preparation is that K-Means is also sensitive to unscaled data, the two variables of interest are scaled in order to use the algorithm.

Statistic	**N**	**Mean**	**St. Dev.**	**Min**	**Max**
Population Growth	5,188	0.000	1.00	−2.795	2.901
Subsidy Growth	5,188	0.000	1.00	−2.888	2.956
Gas Stations	5,188	−0.000	1.00	−0.354	18.830
TERRAIN	5,188	−0.000	1.00	−1.114	1.212

Table 4.6: Descriptive Statistics after the Normalization

While various methods exist to determine the optimal number of clusters (K), it is important to acknowledge that these methods may not consistently converge on a single, definitive value for K. To discern the number of distinct groups within a dataset, several tests have been applied. The provided figures illustrate two distinct methods that yield disparate recommendations regarding the optimal number of clusters for the same dataset.

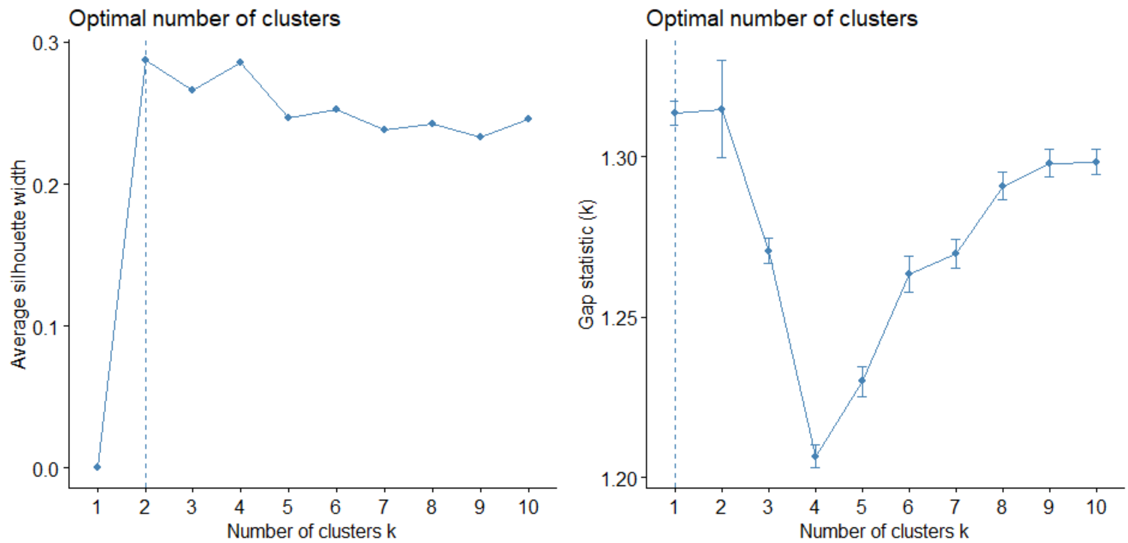

Figure 4.3: Silhouette Coefficient and Gap Statistic Plots.

[1]This implies that the algorithm can process unlabeled data and unordered observations, grouping them based on similar characteristics.

Firstly, the figure incorporates the Silhouette Coefficient on the left side, which assesses the similarities among data points within clusters. Secondly, it includes the Gap-Statistic on the right, a measure that calculates the disparity between the within-cluster dispersion of the original data and the expected dispersion under a null reference distribution. Both tests suggest a very small number of clusters, specifically the Silhouette coefficient maximizes at K=2 while Gap Statistic suggest K=1 for the optimum number of clusters.

The limited number of clusters observed could be due to the presence of random patterns across communities, where various factors beyond population, subsidies, or terrain contribute to actual similarities. A more reliable and accurate method that yielded representative outcomes is the Within Sum Square (WSS) estimator also known as *Elbow Method*. This metric calculates the sum of squared distances between each data point and the center of its assigned cluster (centroid) and the technique to calculate this distances for both K-Means and Elbow method is the Euclidean Distance.

$$WSS = \sum_{i=1}^{k} \sum_{x \in C_i} d(x, c_i)^2 \tag{4.1}$$

Where,

$$d(x, c_i) = \sqrt{\sum_{j=1}^{n} (x_j - c_{ij})^2} \tag{4.2}$$

The symbol x represents the data point while c_i represents the centroid i. The optimal number of clusters is typically identified at the "elbow" of the Total WSS curve, where the redaction of Total WSS slows down. In the context of this study, it appears that K=5 represents a point at which the addition of another cluster may not significantly improve the efficiency.

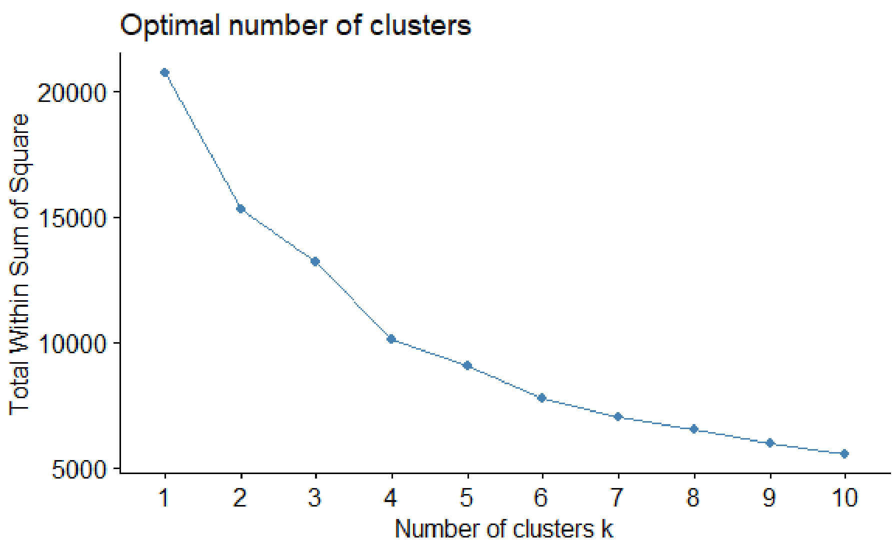

Figure 4.4: Within Sum Squares plot for the Number of Clusters

To explore the interpretation of clusters and assess their effectiveness, it becomes essential to address the issue of overlapping. Although the K-Means algorithm is intended to allocate data points to distinct, non-overlapping clusters, real-world scenarios often involve overlapping clusters. The occurrence of overlap between two clusters can facilitate the identification of interconnections between them.

The following graph displays the visualization of the clusters through K-Means algorithm with the suggestion of WSS estimator after 2.500 runs with different initial sets of cluster centers to increase the likelihood of finding a good solution, leading to a more robust and reliable clustering result.

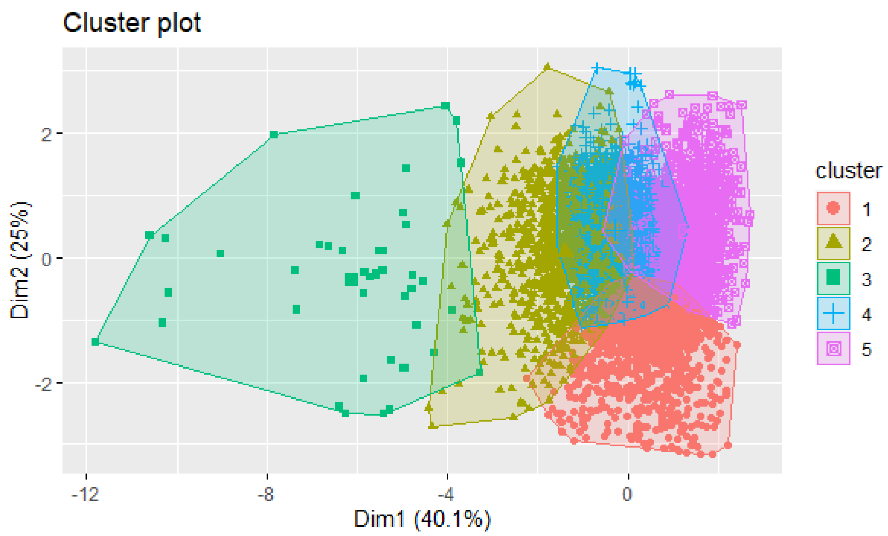

Figure 4.5: Main Cluster Plot for K=5.

It is clear that there is an overlapping between the groups, one possible cause of this is due to the behavior of the communities located on an island. The algorithm captures very precisely the behavior of communities with similar terrain and urban characteristics but some of the island communities do not act very differently from the other. The subsequent table provides a very clear image of the accuracy of the algorithm with the municipal communities and the straggle to identify and characterize the island communities.

The cluster plot serves as a Principal Component plot, where Dim1 and Dim2 on the x and y axes, respectively, depict the first and second principal components. Collectively, these two components contribute to 40.1% and 25% of the variance, explaining a total of 65.1% of the dataset's variation. While this is not considered low, it also falls short of being substantial. To enhance this percentage, incorporating additional independent variables for each community is essential[2]. However, this recommendation remains a subject for future exploration and investigation.

[2]There are many more characteristics of the different communities, in correlation with the agricultural subsidies a very meaningful variable would be the output of each community in EURO, also the employees that work on this industry would be also ideal. The problem is that acquiring these data for each and every municipal community in Greece is difficult, these data are spread across many ministries which use different different encoding for every region.

The following table provides a core explanation of the different features within the clusters. Each group represents a different aspect of the Greek state, capturing phenomena which are evident through out the evolution of agricultural sector. Cluster (1) contains 1,016 communities located in more semi-mountainous regions, subsidies have seen the lowest the reduction while the economic activity is almost noticeable. Cluster (2) contains 1,075 communities and captures a big portion of the island communities this can be seen by the island index, this group is located in lowland regions has witnessed a very small decrease in the population growth rate while the subsidies decreased thirty times more comparing to the population growth, the economic activity is present on these communities.

Cluster (3) contains a more metropolitan regions with nearly every community classified as *Urban*. In this group, it is evident the phenomenon of centralization or urbanization indicated by the positive population growth rate and the very big population density, the economic activity is also very high. The unique finding is that these communities, on average, have almost 3 times the amount of producers comparing to a more rural regions such as in cluster (1), with every Young Farmer receiving the biggest amount of subsidy across the groups.

Moving to cluster (4), it contains 1,665 communities including more agricultural areas indicated by the high Urbanity index (1.98) located in more lowland terrain. This group shows low economic activity while the decrease in population growth almost follows the decrease in subsidy growth. Lastly, cluster (5) contains 1,391 rural communities (urbanity index 1.99) which are located in mountainous areas (terrain index 2.87). This is a very unique group due to the biggest population and subsidy decrease combined with the lowest economic activity, population density and the lowest amount of new young farmers for 2019.

Cluster	**1**	**2**	**3**	**4**	**5**
Communities	1,016	1,075	41	1,665	1,391
Variable					
Pop. Growth	-39.01	-1.45	7.66	-36.13	-50.77
Producers19	74.21	152.58	453.59	125.46	45.13
Young Farmers19	11.90	19.44	70.32	14.30	5.03
Yng Subsidy19	6.27k	7.41k	23.41k	6.35k	2.06k
Urbanity	1.98	1.81	1.02	1.98	1.99
Terrain	2.43	1.41	1.24	1.28	2.87
Density	22.86	129.00	923.09	44.91	13.07
Gas Stations	0.28	1.26	15.16	0.42	0.11
Island	0.25	0.39	0.22	0.21	0.14
Subsidy 11	274.57k	542.66k	1,669.02k	628.53k	212.83k
Subsidy 19	244.12k	355.84k	1,058.75k	367.45k	122.51k
Subsidy Growth	-9.93	-32.59	-27.77	-39.11	-44.53
Mean Growth	-41.91	-44.41	-45.77	-48.03	-45.19

Table 4.7: Summary of Clustering Results with Average Values for Each Community Within the Group.

4.4 Another Classification Approach

A simpler approach is to group the communities based solely on the growth rates of population and subsidies. Therefore, the next model includes only these two variables. The same methodology is applied to this model, the observations have been scaled and normalized ensuring that all variables are given equal weight in the clustering process, leading to less biased cluster assignments. The *Interquartile Range* (IQR) is also calculated to remove the outliers due to the sensitivity of the algorithm to them. The same algorithm is used to create the classification, K-Means, and the Within Sum Square estimation is the method used to identify the optimum number of clusters

Statistic	**N**	**Mean**	**St. Dev.**	**Min**	**Max**
Population Growth	5,234	0.000	1.00	−2.78	2.90
Subsidy Growth	5,234	−0.000	1.00	−2.88	2.96

Table 4.8: Descriptive Statistics of Population and Subsidy Growth Rates after Scaling.

The total number of communities that are included in this model is 5,234 out of 6,130 and this is because of the interquartile approach of outliers, the dataset used for this case is balanced without missing values. In this case, the *Elbow method* is indicating the optimal number of cluster based on these two variables to be K=4, which is expected.

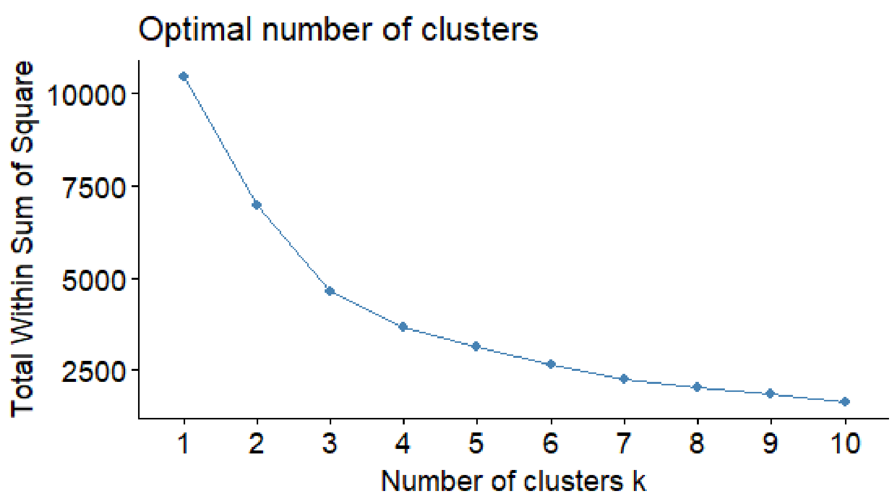

Figure 4.6: Within Sum Squares Plot for the Number of Clusters

The silhouette coefficient for this model suggested K=3. By following this suggestion, the algorithm did not capture any significant difference between the groups. Each group appears to be in a semi-mountainous area with average economic activity. While these results may represent the groups, they do not provide useful information or interpretation. The gap statistic also suggested K=1, which will not be considered a valid suggestion. Thus, K=4 seems to capture some very useful insights, and this will be the selected number for clusters. In the following section, an exploration of the clusters will be presented.

The difference between this model and the previous one is that now there is no overlapping across clusters. The following figure displays the K-Means output for K=4 using only the growth rates of population and subsidies after 2,500 runs of the algorithm.

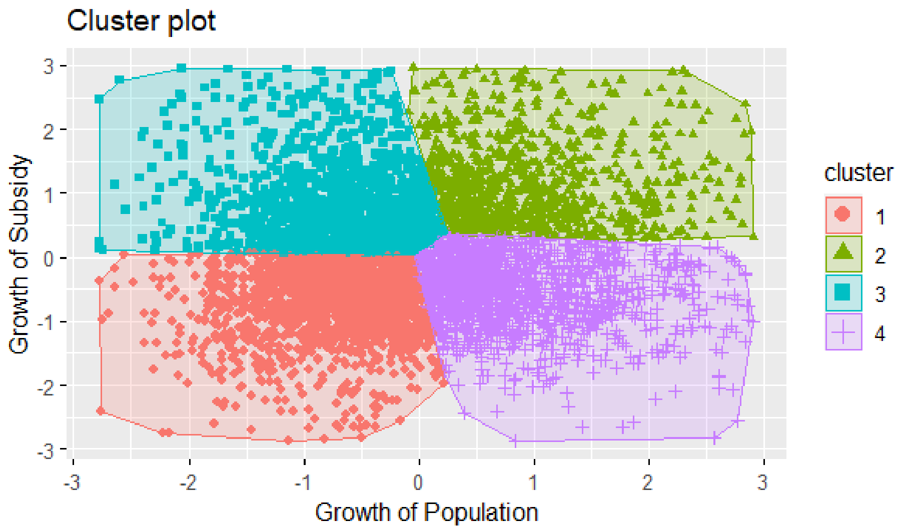

Figure 4.7: Cluster Plot for K=4.

The variance explained by this classification was found to be equal to 64.8%, not significantly different from the initial output. Although the variance is relatively high, this model struggles to capture important details within the clusters. The communities are classified into the following groups:

1. Low subsidy growth, Low population growth
2. High subsidy growth, High population growth
3. High subsidy growth, Low population growth
4. Low subsidy growth, High Population growth

Cluster (1) includes communities with relatively high altitude and low population density, situated in mountainous regions with nearly no economic activity. In contrast, cluster (2) includes communities with urban characteristics, high population density, and intense economic activity, combined with a small decrease in subsidy growth rate. Cluster (3) encompasses communities located in semi-mountainous areas, characterized by relatively small population density, none to low economic activity, and an equally low decrease in population growth compared to cluster (1). Lastly, cluster (4) includes two types of communities: those with relatively high population density and those located on islands, where economic activity seems to be present.

It's worth noting that "*Low Growth Rate*" translates to a low decrease in growth rate, while "*High Growth Rate*" refers to a significant decrease in growth rate. This applies to both population and subsidy growth rates. As seen in previous sections, both variables declined as the time passed.

4.5 Efficiency Index

In the preceding section, the efficiency index is introduced. The interpretation of this index is starting by an examination of its distribution, which delivers crucial insights. On average, the index exhibits a central tendency below 1 but also surpasses 3. This suggests that, generally, a further rise in the growth rate of subsidies won't significantly affect population growth but it will be evident. However, communities with a CEI greater than 1 will exert a more substantial impact on population growth, with the influence increasing as the index becomes larger.

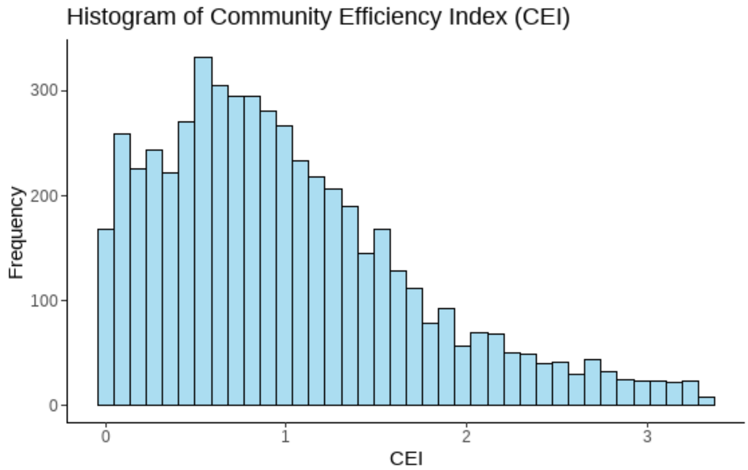

Figure 4.8: Distribution of Community Efficiency Index.

The same result is displayed when the examination of the CEI distribution is grouped by the terrain variable[3]. The unique finding is that both Semi-Mountainous and Mountainous regions seems to be more influenced than the Lowland regions, parallel findings with linear regression.

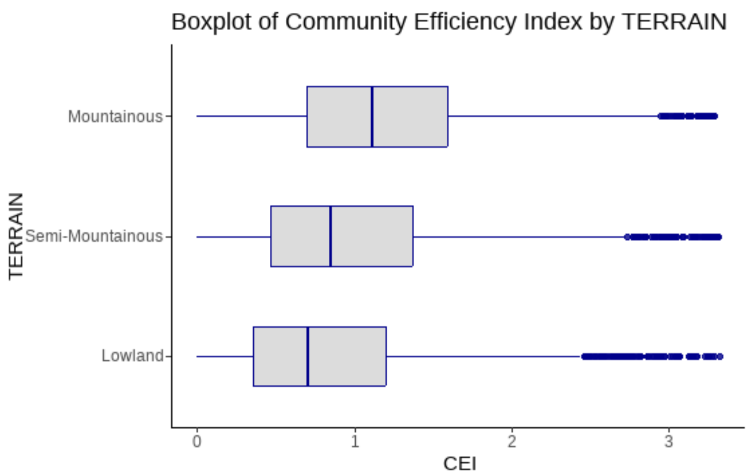

Figure 4.9: Distribution of Community Efficiency Index by Terrain.

[3]It is worth to note that the island communities did not displayed significant difference in efficiency compared to mainland areas so the investigation of these communities regarding to efficiency is not presented.

4.6 Neighbor Communities Comparison

Hellenic Statistic Authority provides shape files which contain the perimeter and geometry of each administrative unit, for the purpose of this analysis the geometry of municipal communities have been used. The polygons are used to obtain the boarded length of each unit, using it as a set it is easy to find the tangent between the neighboring sets, in this case, the communities that are tangent with each other. Using a loop, repeatedly through each polygon, finding its intersections with others and identifying the maximum shared space the closest neighbors are identified.

The comparison is conducted within groups of communities, considering the variables of terrain, urbanity, and island. Each group is analyzed from two perspectives: communities that exhibit higher efficiency/influence than their best neighbors and those that score lower than their "best" neighbor. The instrumental variable "Comparison" signifies the contrast between a community and its neighbor, with a value of 1 indicating that the community will achieve better influence and 0 indicating that the neighbor will be less influenced.

4.6.1 Urbanity Comparison

By grouping the communities with the CEI index it is possible to compare these two groups. The ensuing table presents the initial comparative analysis focusing on urban and rural communities. In the context of urban areas (urbanity equals to 1), communities characterized by higher levels of population growth, significant negative subsidy growth, and relative smaller population density found superior efficiency in comparison to their neighboring. A parallel observation holds true for rural communities however, now the population and subsidy growth present. Notably, in both urban and rural regions, the communities with better efficiency displayed negative subsidy growth.

URBANITY	1	1	2	2
Comparison	0	1	0	1
Population Growth	-0.33	5.63	-28.17	-36.22
Producers2019	263.22	259.53	87.51	88.41
Young Farmers	35.44	39.34	10.85	10.80
ISLAND	0.22	0.20	0.24	0.25
TERRAIN	1.38	1.38	1.98	1.95
DENSITY	776.38	649.46	41.03	37.42
Gas Stations	5.39	4.48	0.41	0.34
Subsidy Growth	12.60	-24.08	10.37	-32.21
CEI	**0.39**	**0.96**	**0.82**	**1.28**

Table 4.9: Comparison Between Urban and Rural Areas with Neighboring Communities.

4.6.2 Terrain Comparison

The terrain variable provides additional insights from the perspective of efficiency. Notably, lowland communities exhibit, on average, the lowest Community Efficiency Index (CEI) among the various groups. Furthermore, when comparing the population density of lowland communities that will be influenced more than their neighbors, it appears that the gap in population density gets smaller as the altitude increases. Additionally, semi-mountainous regions contain the vast majority of island communities.

While this observation warrants further investigation, it remains a suggestion for future research. Lastly, mountainous areas demonstrate the biggest CEI, emphasizing the fact that, compared to other groups, these regions will face the most significant impact in population change as a result of an increase in agricultural subsidies.

This specific comparison revealed several noteworthy observations. The disparity between communities where the comparison is 1 and those where it is 0 expands as the altitude increases. To illustrate, for lowland (1) communities, the difference is 0.51, while for semi-mountainous (2) communities, it increases to 0.55, and further rises to 0.66 for mountainous (3) communities. This suggests that lowland communities do not exhibit a significant difference from their best neighbor, whereas communities in mountainous areas may demonstrate substantial distinctions from their closest neighbors[4] while almost every subsidization in these region will be have great influence in population change.

TERRAIN Comparison	1 0	1 1	2 0	2 1	3 0	3 1
Population Growth	-16.73	-23.23	-23.52	-33.31	-37.79	-48.36
Producers2019	146.56	130.82	103.54	102.30	53.32	50.55
Urbanity	1.83	1.91	1.93	1.96	1.97	1.99
Density	225.29	130.31	54.03	37.76	17.44	13.77
Gas Stations	1.54	0.92	0.69	0.46	0.26	0.16
Island	0.26	0.22	0.36	0.38	0.15	0.15
Subsidy Growth	17.34	-32.20	39.57	-30.63	-20.46	-32.24
CEI	**0.64**	**1.11**	**0.75**	**1.26**	**0.98**	**1.48**

Table 4.10: Comparison Between Lowland, Semi-Mountainous and Mountainous Areas with Neighboring Communities.

[4]Comparing the "best neighbors" among neighboring communities can involve diverse approaches. These include considering geographical proximity, emphasizing the nearest neighbor based on physical distance, and looking at demographic similarities. Economic factors, defined by similar economic activities or industries, and infrastructure accessibility are also considerations.

4.6.3 Island Comparison

The next table present the comparison between mainland and island communities. The influence disparity between neighboring communities is notably pronounced on the islands. The CEI for island communities differs by 0.51 between communities where the comparison is 1 and those where it is 0, suggesting a apparent yet less prominent difference compared to lowland regions. Island communities with relative big population density appear to influenced less from the agricultural subsidies. In the more efficient communities, there appears to be bigger reduction in population growth, while the contrast in economic activity is not substantial. Additionally, island communities with a comparison of 1 seem to be situated at a higher altitude compared to those with a comparison of 0 but this difference is also not significant.

ISLAND	0	0	1	1
Comparison	0	1	0	1
Population Growth	-29.27	-38.57	-14.03	-20.23
Producers2019	100.01	93.16	117.55	108.69
Urbanity	1.90	1.95	1.92	1.95
Terrain	1.98	1.95	1.77	1.83
Density	116.97	67.96	94.98	67.51
Gas Stations	0.92	0.55	0.80	0.54
Subsidy Growth	-13.07	-31.41	82.55	-33.06
CEI	**0.85**	**1.32**	**0.59**	**1.10**

Table 4.11: Comparison Between Island and Mainland with Neighboring Communities.

4.6.4 Closing Notes

This comparative analysis has unveiled significant findings regarding the elasticity of population in relation to agricultural subsidies across various categories within municipal communities. While acknowledging the possibility of additional groups, the examination primarily focuses on the most common types of communities in Greece. Furthermore, the results of the efficiency index indicate that mountainous areas exhibit the most effective utilization of subsidies, whereas urban communities appear to be on the opposite side. Notably, communities that consistently outperformed their neighbors (displaying bigger CEI) demonstrated lower economic activity in the area. This trend is reflected in both the total number of producers and the average subsidy growth rate. However, the most valuable observation is that communities experiencing the greatest subsidy reduction will have the most significant impact on population. The next section contains the conclusions of this study, along with the final thoughts of this analysis.

Chapter 5

Conclusion

This study presents a unique approach to addressing Greece's depopulation challenge, which has been prominent over the past decade. Observations indicate a consistent decline in the population, as individuals increasingly opt to relocate from rural and agricultural landscapes to larger metropolitan and urban centers. This trend is not unique to Greece but is observed globally, and Greece is no exception, with certain communities experiencing up to a 50% reduction in population. To foster population growth, it is crucial to provide support to rural areas. Despite approximately 83% of communities in Greece being classified as rural, meaning their population is below 2,000, support for these regions remains notably limited. While the rural-urban relocation phenomenon is well-documented and the reasons that ignite this are numerous, this study specifically explores the impact of agricultural subsidies on population dynamics at the municipal community level.

The analysis of linear regression models revealed an approximation of the observed impact. In order to achieve this, a baseline simple linear regression model was constructed, integrating solely the subsidy growth rate as an independent variable and the population growth rate as the dependent variable. The estimation of this model is done by using the Ordinary Least Squares estimator, under the assumptions of a Simple Linear Model. The findings indicated a negative coefficient for the constant term, implying that without intervention from administrative units, population growth rate could potentially decline by up to 30%, additionally, increasing the subsidy growth will result in positive population growth translating to the fact that agricultural subsidies actually can be a solution to the depopulation problem in rural areas.

By building a multiple linear regression model and comparing it with the baseline model, it was uncovered that subsidies play a crucial role in population growth. However, the economic activity of the area and the terrain where the community is located were identified as having a more substantial impact on population growth. Concerning terrain, the results indicated that communities found in mountainous regions would experience approximately 3.5 times greater population growth if economic activity is increased. Moreover, the constant term in mountainous areas is relatively more substantial compared to semi-mountainous or lowland regions, signifying that these communities could face the most considerable decline in population if no action is taken.

An additional striking discovery emerged when the population growth rate variable was replaced by the average subsidy growth. This replacement uncovered an unusual negative relationship between average subsidy growth and population growth meaning that it would be more effective to raise the total subsidy rather than the average subsidy support. Lastly, a meaningful surprise came to light during the isolation and examination of communities in separate groups. It was found that communities situated in mountainous areas and those located on islands exhibited the largest negative, statistical significant constant term across all groups. Furthermore, population density appeared to have a positive impact, almost four times larger, on population growth, suggesting that areas with higher population density are more likely to experience better population development.

An important reminder is that correlation doesn't mean causation, by increasing the agricultural subsidies linear regression analysis revealed that will have positive influence on population growth in rural communities but this doesn't mean that only this action is needed in order to increase the population. It is evident that different groups will benefit more through agricultural subsidies thus, a classification is needed in order to identify the distinguishing group of which the subsidies will be more effective. By employing K-Means Algorithm, in order to capture the different characteristics within the cluster, valuable information was identified.

Two categorizations have been implemented, with the initial classification containing five clusters. Each cluster encompasses communities exhibiting very similar patterns in terms of population and subsidy growth, economic activity, and terrain characteristics. The algorithm precisely captures the phenomenon of urbanization within this classification, showcasing features such as high population density, lowland locations, and nearly every community labeled as urban with substantial economic activity within the group. Island communities do not found to have a unique behavior, this may be due to the algorithm specification. Another interesting finding is that island communities, despite exhibiting relatively low economic activity and a significant decrease in the subsidy growth rate, they did not experience an equal and substantial impact on the population. This anomaly can be attributed to the fact that this group comprised approximately 152 producers per community in 2019. Given this considerable number, a more substantial influence on population reduction was expected due to the decrease in subsidies.

Cluster analysis revealed the behavior of metropolitan areas, demonstrating positive population growth, a relatively modest reduction in the subsidy growth rate compared to other groups, and notably the highest subsidy per community. The findings indicate that a significant portion of government funding per community is directed towards producers in urban areas rather than rural regions. This suggests a trend where individuals are opting to move away from the countryside while still engaging in agricultural activities, indirectly supporting farmers or farming industry.

An alternative application relies solely on subsidy and population dynamics. This method appeared to identify that rural and mountainous communities witnessed the most significant reduction in both population and subsidy growth. It clarified that producers located in remote regions with low economic activity and high altitude received the lowest subsidy per producer.

This behavior differs from the ambitious vision that the European Union portrays with the Common Agricultural Policy. The objectives of this policy are clear, with the majority oriented towards population development in remote regions.

The last qualitative analysis is centered around the comparison of the efficiency across different groups and afterwards between neighboring communities. At the first glance it seems that, on average, every community utilizes the subsidies relative efficiently providing influence to the population change. Unlike other group, communities located in mountainous regions seem to be more efficient comparing it to lowland or semi-mountainous communities. This is expected due to the almost none existent economic activity in these areas.

Furthermore, the comparison between neighbors revealed the gap difference that exists among neighbors, mountainous communities seem to have the biggest difference with their neighbors while lowland regions do not displayed significant difference. In each case, communities experiencing a larger reduction in subsidization will likely undergo the most considerable increase in population growth. Understanding the gap between efficient and inefficient neighbors can be a striking finding for the utilization of the LEADER program. This policy is well-established in Greece and the gap in efficiency, that revealed to exist through this study, between communities can be minimized by fostering the communication between the two sides, potentially resulting in a significant efficiency boost.

In summary, this study has revealed the various factors influencing population growth. While depopulation is a complicated subject with numerous underlying causes and even more negative affect, agricultural subsidies have been identified as mitigating its impact, particularly in rural areas. To address challenges within the agricultural sector, directing funding towards infrastructure to enhance farmer productivity emerges as a more advantageous approach. It is evident that, more regulations of the subsidy usage is in need, this can prevent negative outcomes or inefficient subsidy spending. Future research opportunities may include an exploration of the significance of public services in agricultural regions, access to hospitals, schools, administrative services, offering insights into another dimension that could contribute significantly to population changes. Additionally, a suggested frontier analysis could focus on isolating and improving the input and output variables within the sector, aiming to enhance overall efficiency and especially in mountainous regions.

Bibliography

Ghorbani et al. (2020). *Resources Use Efficiency in Agriculture*, Chapter Technical Efficiency in Agriculture, pp. 329–347. Springer.

Papadopoulos A. (2015). The Impact of the CAP on Agriculture and Rural Areas of EU Member States. *Agrarian South: Journal of Political Economy 4*(1), 47–49.

Polinesi et al. (2020). Population Trends and Urbanization: Simulating Density Effects Using a Local Regression Approach. *Geo-Information 9*(7), 454.

Rastislav et al. (2020). Assessing Impacts of CAP Subsidies on Financial Performance of Enterprises in Slovak Republic. *Sustainability 12*(3), 948.

Abeliotis K. and Doudoumopoulos K. (2019). *Urban Farming in the Era of Crisis in Greece: The Case Study of the Urban Garden of Ag. Anargiri-Kamatero and Fili*, pp. 179–186. Springer.

Amores A. and Conteras I. (2009). New approach for the assignment of new European agricultural subsidies using scores from data envelopment analysis: Application to olive-growing farms in Andalusia (Spain). *European Journal of Operational Research 193*(3), 718–729.

Bholowalia P. and Kumar A. (2014). EBK-Means: A Clustering Technique based on Elbow Method and K-Means in WSN. *International Journal of Computer Applications 105*(9), 17–24.

Biffi et al. (2021). Aligning agri-environmental subsidies and environmental needs: a comparative analysis between the US and EU. *Environmental Research Letters 16*(5), 12–13.

Bojnec S. and Fertő I. (2022). Do different types of Common Agricultural Policy subsidies promote farm employment. *Land Use Policy 112*(6), 105823.

Bonfiglio et al. (2017). Are rural regions prioritizing knowledge transfer and innovation? Evidence from Rural Development Policy expenditure across the EU space. *Journal of Rural Studies 53*(4), 78–87.

Chatzitheodoridis F. and Kontogeorgos A. (2020). New entrants policy into agriculture: researching new farmers' satisfaction. *Revista De Economia E Sociologia Rural 58*(1), 8–14.

Ciommi et al. (2020). Population dynamics, agglomeration economies and municipal size. A long-term analysis. *Jura - Juristische Ausbildung 11*(1), 13–14.

Dudu H. and Kristkova Z. (2017). Impact of CAP Pillar II Payments on Agricultural Productivity. Technical report, Publications Office of the European Union.

Duquenne et al. (2019). Contribution of the Common Agricultural Policy to agricultural productivity of EU regions during 2004–2012 period. *Review of Agricultural, Food and Environmental Studies 100*(1), 47–68.

Díaz-Puente et al. (2022). The main risk factors for rural innovation in Europe: an analysis of 200 case studies. *European Journal of Innovation Management 26*(22).

European Commission (2023). Fact sheet on the rural development programme of Greece 2014-2022. Technical report, European Committion.

European Council (2023). Timeline - History of the CAP. Technical report, Council of the European Union.

European Court of Auditors (2022). Leader and community-led local development facilitates local engagement but additional benefits still not sufficiently demonstrated. Technical report, European Court of Auditors. Special Report "10" of 2022.

European Network of Rural Development (2022). LEADER/CLLD explained.

European Publication Office (2023). A GREENER AND FAIRER CAP. Technical report, European Commission.

Federico et al. (2019). Economic downturns and compositional effects in regional population structures by age: a multi-temporal analysis in Greek regions, 1981–2017. *Quality Quantity 53*(3), 2614–2615.

Garrone et al. (2019). Jobs and agricultural policy: Impact of the common agricultural policy on EU agricultural employment. *Food Policy 87*(3), 11–12.

Georgiadis et al. (2021). Farming practices and biodiversity: Evidence from a Mediterranean semi-extensive system on the island of Lemnos (North Aegean, Greece). *Journal of Environmental Management 303*(2), 114131.

Getimis P. (2021). *Local State-Society Relations in Greece*, pp. 165–180. Springer International Publishing.

Gkatsikos et al. (2022). An Impact Assessment of the Young Farmers Scheme Policy on Regional Growth in Greece. *Sustainability 14*(5), 2888.

Graves C. (1965). Two multiple regression models of small-area population change. *Highway Research Board 1*(102), 42–53.

Grodzicki T. and Jankiewicz M. (2022). The role of the common agricultural policy in contributing to jobs and growth in EU's rural areas and the impact of employment on shaping rural development: Evidence from the Baltic States. *PLoS ONE 17*(12), 1–14.

Guangqing C. and Donghui W. (2017). *Small-Area Population Forecasting: A Geographically Weighted Regression Approach* , Chapter 21, pp. 2–6. Springer.

Hellenic Statistic Authority (2023). Results of the Population-Housing Census for the year 2021 concerning the Permanent Population of the Country. Technical report, Hellenic Statistic Authority.

Helming J. and Tabeau A. (2018). The economic, environmental and agricultural land use effects in the European Union of agricultural labour subsidies under the Common Agricultural Policy. *Regional Environmental Change 18*(3), 769–773.

Karagiannis G. and Sarris A. (2002). Direct Subsidies and Technical Efficiency in Greek Agriculture. Technical report, European Association of Agricultural Economists.

Karantininis K. (2017). *A New Paradigm for Greek Agriculture*, Chapter Overview of Greek Agriculture, pp. 5–11. Springer International Publishing.

Kasimis C. and Papadopoulos A. (2001). *Europe's Green Ring*, Chapter The De-agriculturalisation of the Greek Countryside: The Changing Characteristics of an Ongoing Socio-economic Transformation, pp. 197–218. Routledge.

Katsoulakos N. and Kaliampakos D. (2016). Mountainous areas and decentralized energy planning: Insights from Greece. *Energy Policy 91*(0301-4215), 174–188.

Koutsoukos M. and Iakovidou O. (2013). Factors Motivating Farmers to Adopt Different Agrifood Systems: A Case Study of Two Rural Communities in Greece. *Rural society 23*(1), 3522–3540.

Lafazani P. and Lagarias A. (2016). Applying multiple and logistic regression models to investigate periurban processes in Thessaloniki, Greece. *Geocarto International 23*(1), 32–45.

Lakasas Y. (2022). Intention and attitude of agri-food industry and agricultural specialists toward the adoption of precision agriculture technologies in Greece. Master's thesis, International Hellenic University.

Latruffe et al. (2017). Subsidies and Technical Efficiency in Agriculture: Evidence from European Dairy Farms. *American Journal of Agricultural Economics 99*(3), 783–799.

Marian et al. (2013). CAP Subsidies and Productivity of the EU Farms. *Journal of Agricultural Economics 64*(3), 537–557.

Mavridis S. (2018). Greece's Economic and Social Transformation 2008–2017. *Social Sciences 7*(1), 1–14.

Metaxas et al. (2017). Improving service quality to local communities via a citizen satisfaction measurement in Greece: The 'MUSA' approach. *Journal of Developing Areas 51*(3), 77–101.

Murray et al. (2020). Billions in Misspent EU Agricultural Subsidies Could Support the Sustainable Development Goals. *One Earth 3*(2), 237–250.

Panagiotopoulos G. and Kaliampakos D. (2019). Acessibility and Spatial Inequalities in Greece. *Applied Spatial Analysis and Policy 12*(3), 1–20.

Paschalidis et al. (2018). The european union's common agricultural policy and development of agro-food sector in Greece. *RUDN Journal of Agronomy and Animal Industries 13*(4), 373–382.

Pazarskis et al. (2019). Do municipal mergers work? Evidence from municipalities in Greece. *Journal of Governance and Regulation 8*(2), 61–67.

Pengfei et al. (2023). The effect of agriculturalsubsidies on chemical fertilizer use: Evidence from a new policy in China. *Journal of Environmental Management 344*(3), 118423.

Pierrakos et al. (2019). *The Evolution of Demographic Changes in Greek Society and Proposed Administrative Management Model*, pp. 645–651. Springer.

Publications Office of the European Union (2017). Agriculture. Technical report, The European Union Explained.

Pylypenko I. and Malchykova D. (2022). Regression analysis of demographic processes: spatial results (kherson region case, ukraine). *SGEM WORLD SCIENCE (SWS) Scholarly Society 9*(1).

Rachman et al. (2021). An analysis of population using Multiple Linear Regression Analysis. *IOP Conference Series: Materials Science and Engineering 1088*(1), 012091.

Rezitis et al. (2002). Measuring technical efficiency in the Greek agricultural sector. *Applied Economcis 34*(11), 1345–1357.

Salhofer K. and Feichtinger P. (2020). Regional differences in the capitalisation of first and second pillar payments of the CAP into land rental prices. *European Review of Agricultural Economics 48*(1), 8–41.

Salvati L. (2018). Population growth and the economic crisis: understanding latent patterns of change in Greece, 2002–2016. *Letters in Spatial and Resource Sciences 11*(2), 105–126.

Salvati L. (2020). Population structure and economic cycles in greece: a multidimensional regional analysis (1988-2016). *Jura - Juristische Ausbildung 10*(1), 61–78.

Salvia et al. (2020). In-Between 'Smart' Urban Growth and 'Sluggish' Rural Development? Reframing Population Dynamics in Greece, 1940–2019. *Sustainability 12*(15), 6165.

Saraceno, E. (2003). Rural development policies and the secon pillar of the common agricultural policy. In *Policy vision for sustainable rural economies in an enlarged Europe*, pp. 197–222. ARL – Akademie für Raumentwicklung in der Leibniz-Gemeinschaft.

Shatolova et al (2022). Cluster analysis and classification of Russia's industrial oriented regions by economic specialization. *Èkonomika i matematičeskie metody 58*(1), 80–91.

Soliwoda M. (2016). The impact of the support instruments of the Common

Agricultural Policy on economic and financial stability of farms in EU countries. *Acta Universitatis Lodziensis. Folia Oeconomica 2*(319), 99–116.

Sonagara D. and Badheka S. (2014). Comparison of Basic Clustering Algorithms. *International Journal of Computer Science and Mobile Computing 3*(10), 58 – 61.

Staniszewski J. and Borychowski M. (2020). The impact of the subsidies on efficiency of different sized farms. Case study of the Common Agricultural Policy of the European Union. *Agricultural Economics-zemedelska Ekonomika 66*(8), 373–380.

Stratigea et al. (2017). *Smartening-Up Communities in Less-Privileged Urban Areas—The DemoCU Participatory Cultural Planning Experience in Korydallos—Greece Municipality* , Chapter Chapter 4, pp. 85–112. Springer.

Svoboda et al. (2016). Subsidies on Investments in the EU Member States. *Agris on-line Papers in Economics and Informatics 8*(4), 153–162.

Swanson D. and Tayman J. (2015). *On the Ratio-Correlation Regression Method of Population Estimation and Its Variants*, Chapter 8, pp. 93–118. Springer.

Terkenli T. (2004). Landscape research in Greece: an overview. *Belgeo 2*(2), 277–288.

Triyana et al. (2023). The Effect of Agricultural Input Subsidies on Productivity: A Meta-Analysis. Technical Report 10399, The World Bank.

Verbeek M. (2017). Using linear regression to establish empirical relationships. *The IZA World of Labor 336*, 1–11.

Appendix A

Visualizations

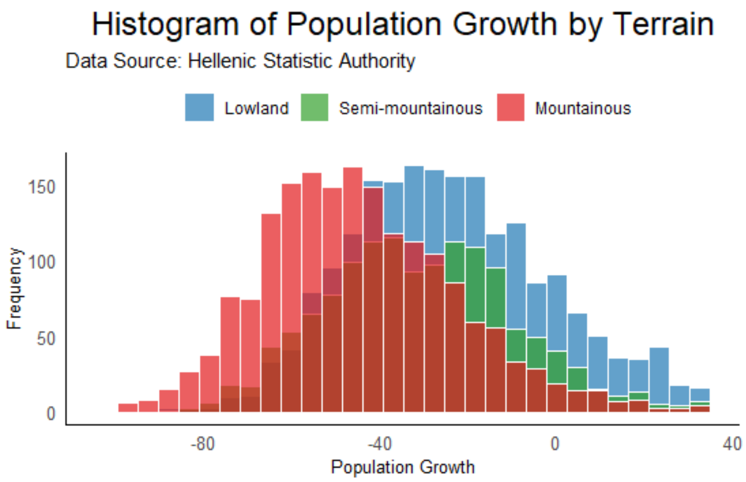

Figure A.1: Histogram of Subsidy Growth Rate by Urbanity

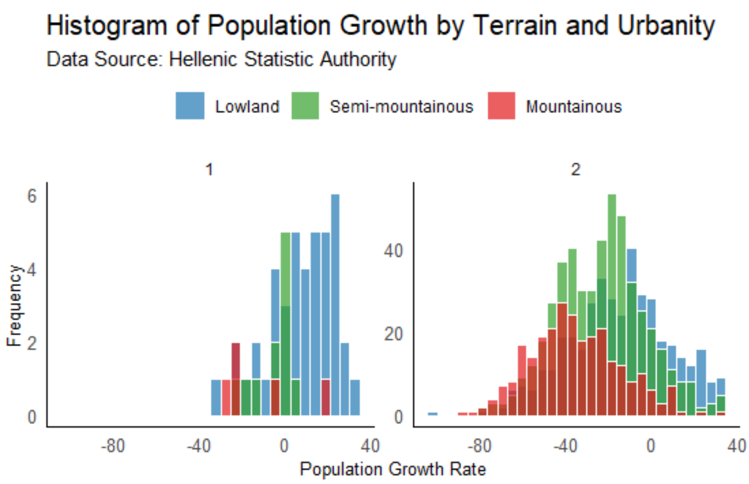

Figure A.2: Histogram of Population Growth Rate by Terrain and Urbanity for Island Communities

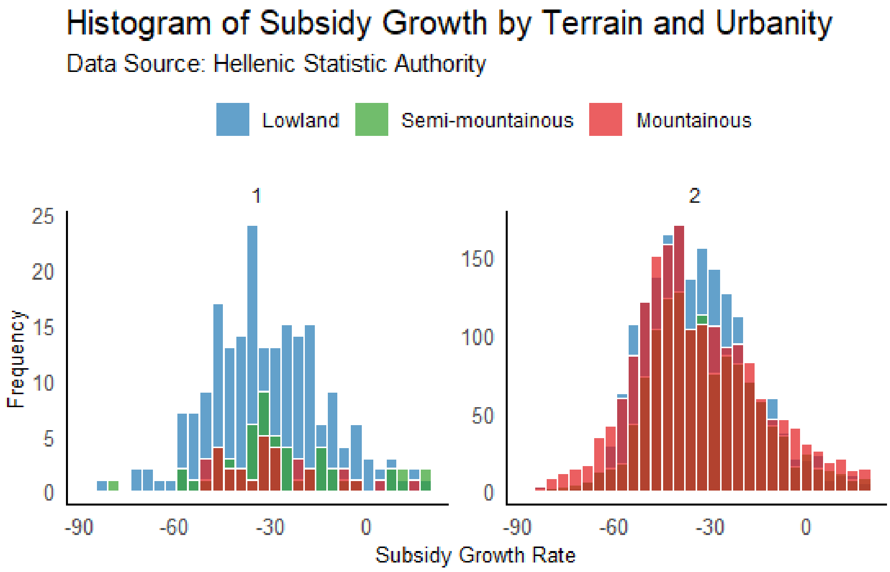

Figure A.3: Histogram of Subsidy Growth Rate by Urbanity

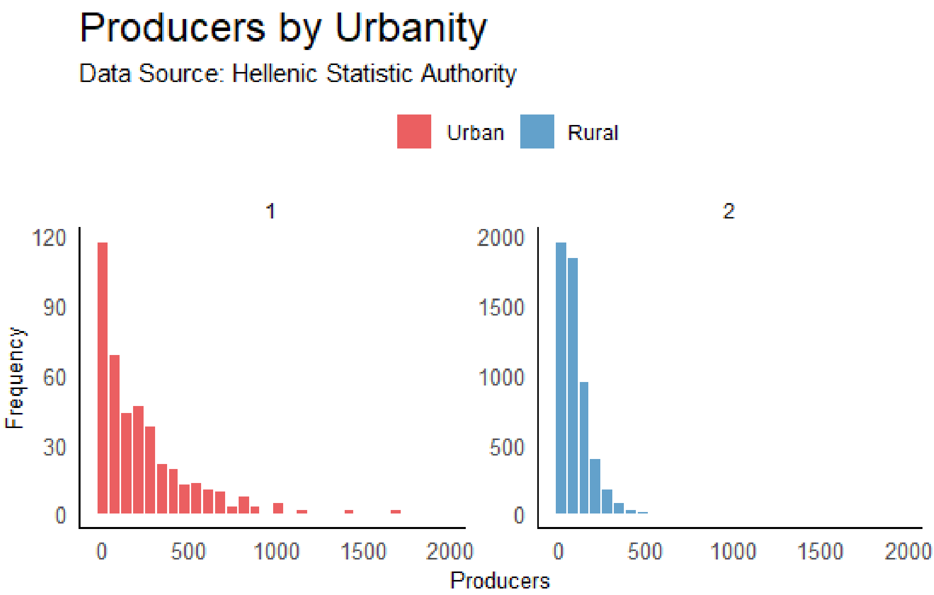

Figure A.4: Histogram of the Total Number of Producers by Urbanity

Appendix B

Code Samples

Listing B.1: First Degree Neighbors

```
shp <- shp %>%
  select(KALCODE, geometry)

neighbors <- as.data.frame(st_touches(shp$geometry))

colnames(neighbors) <- c("KALCODE", "Neighbor")

shp_geom <- shp %>%
  select(KALCODE, geometry)

shp_num <- shp_geom %>%
  mutate(ID = row_number()) %>%
  st_drop_geometry()

neighbors_df <- inner_join(neighbors,
    shp_num,
    by = c("KALCODE" = "ID"))

neighbors <- inner_join(neighbors_df,
    shp_num,
    by = c("Neighbor" = "ID"))


neighbors <- neighbors %>%
  select("KALCODE" = KALCODE.y,
  "NEIGHBOR" = KALCODE.y.y)
```

Listing B.2: The "Best" Neighbor

```

 shp60 <- shp %>%
     select(KALCODE, geometry)


find_best_neighbor <- function(community, shp, neighbors) {

community_neighbors <- neighbors %>%
        filter(KALCODE == community$KALCODE) %>%
        pull(NEIGHBOR)


neighbor_data <- shp %>%
        filter(KALCODE %in% community_neighbors)


intersections <- st_intersection(community,
     neighbor_data,
     by_feature = TRUE)

if (nrow(intersections) > 0) {

        border_lengths <- st_length(intersections)


        best_neighbor <- neighbor_data[which.max(border_lengths), ]

        result_df <- data.frame(
          KALCODE = community$KALCODE,
          max_border_length = max(border_lengths),
          neighbor_KALCODE = best_neighbor$KALCODE,
          stringsAsFactors = FALSE
        )
} else {

        result_df <- data.frame(
          KALCODE = community$KALCODE,
          max_border_length = NA,
          neighbor_KALCODE = NA,
          stringsAsFactors = FALSE
        )
     }

     return(result_df)
}


```

```
result_df <- lapply(1:nrow(shp60), function(i) {
    find_best_neighbor(shp60[i, ], shp, neighbors)
  })


result_df <- do.call(rbind, result_df)


View(result_df)
```

Listing B.3: First and Second Degree Neighbors

```

koin <- final %>%
  select(KOD11)


koin_filtered <- koin %>%
  filter(KOD11 %in% neighbors$KALCODE)


neighbors_first <- neighbors %>%
  inner_join(koin_filtered,
  by = c("KALCODE" = "KOD11")) %>%
  select(KALCODE, NEIGHBOR)

neighbors_second <- neighbors %>%
  inner_join(neighbors_first,
  by = c("KALCODE" = "NEIGHBOR"),
  relationship = "many-to-many") %>%
  select(KALCODE, NEIGHBOR)

koin_nei <- neighbors_second %>%
  filter(KALCODE %in% urban_koin_filtered$KOD11)

View(koin_nei)
```