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The Spillover Effects of Lisbon's Gentrification up to 2041

Assessing Demographic Trends in the Setúbal Peninsula Through a
Business Intelligence Approach

Bernardo Moraes Scherer

Master Thesis

presented as partial requirement for obtaining a Master's Degree in Information Management

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação

Universidade Nova de Lisboa

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by

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Information Management, with a specialization in Business Intelligence

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism, any form of undue use of information or falsification of results along the process leading to its elaboration. I further declare that I have fully acknowledged the Rules of Conduct and Code of Honor from the NOVA Information Management School.

[Lisbon, July 1st, 2025]

Bernardo Moraes Scherer

DEDICATION

To my girlfriend, best friend, and life partner, who inspires me every day to be a better person. Danielle, I never thought I would ever be so lucky and fulfilled.

To my parents, Henri and Jorgea, for their tireless and enduring efforts to always provide me with the best, with endless love. I will never be able to fully retribute such commitment.

To my brother Henrique, for being my greatest example and best friend. The best gift anyone can ever receive is a brother to share life with.

To my grandparents, for paving the way for all of our success, and for never doubting my potential. Not even for a single moment. All my gratitude and admiration for the four of you.

Thank you, for everything, and for so much.

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ABSTRACT

In the past years, Lisbon has been undergoing an intensive process of gentrification, contributing to the displacement of long-term residents and increased living costs, generating a sub-process of the phenomena into the suburban areas, in a cascading effect. This research aims to understand to what extent are the Lisbon's gentrification-driven pressures shaping and influencing the demographic dynamics of the Setúbal Peninsula, and how to strategically measure and display the region's key demographic indicators to foresight upcoming infrastructural pressures. Thus, the research focuses on (1) assessing the current demographic structure and evolution of the Setúbal Peninsula, analyzing key indicators, (2) defining and developing KPIs to quantitatively measure structural changes potentially driven by spillover pressures and (3) conducting a foresight analysis to project the region's population up to 2041, considering three different scenarios through the application of the Cohort-Component Method, aiming to compare possible future demographic shifts and their implications for regional planning and urban livability. Aiming to accomplish the established goals, the research follows the Design Science Research Methodology (DSRM), in which an end-to-end BI solution is designed and developed within the Microsoft Fabric environment, in order to serve as an analytical tool for supporting data-driven urban planning, displaying meaningful KPIs regarding the demographic trends in the Setúbal Peninsula, and generating high value by providing accurate and straightforward answers to the research objectives while also enabling truthful data-driven decision making in the core of the demographic field. Research findings suggest that the demographic trends in the Setúbal Peninsula will be showing signs of deceleration after 2036, representing a saturation of absorptive capacity and growing infrastructural pressures, highlighting the symptoms of a cascading gentrification effect, with the Peninsula inheriting the same issues once dominant in the city of Lisbon. It reinforces the importance of regional urban planning and sustainable urban policies, in order to anticipate and mitigate these negative and inevitable externalities, ensuring an acceptable level of urban livability in the affected areas.

KEYWORDS

Gentrification; Suburbanization; Setúbal Peninsula; Demographic Trends; Business Intelligence; Cohort-Component Method

Sustainable Development Goals (SDG):



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LIST OF ABBREVIATIONS AND ACRONYMS

AAGR	Average Annual Growth Rate
BI	Business Intelligence
DAX	Data Analysis Expressions
DSRM	Design Science Research Methodology
ETL	Extract, Transform, Load
FK	Foreign Key
GFR	General Fertility Rate
IMR	Infant Mortality Rate
INE	Instituto Nacional de Estatística
KPI	Key Performance Indicators
LMA	Lisbon Metropolitan Area
MGR	Migration Growth Rate
NGR	Natural Growth Rate
PK	Primary Key
UN	United Nations Organization

1. INTRODUCTION

Throughout the past decade, the city of Lisbon has been going through significant demographic transformations, driven by an exponential growth of tourism and foreign investment attraction policies (Estevens et al., 2023), which has been leading the Portuguese capital into an intensive process of gentrification (Mendes, 2023). This phenomenon has contributed to the displacement of long-term residents and increased living costs (Mendes, 2023), directly affecting urban livability in the region, including Lisbon's Metropolitan Area and, naturally, the Setúbal Peninsula (Louro, et al. 2021).

Even though gentrification and the rising cost of living might be seen as key drivers of displacement, the classic gentrification concept is nowadays facing a significant change (Silva, 2022; Figueiredo, 2022). If once it was exclusively focused on real estate dynamics and population substitution in the metropolis centers, now it must be observed with a deeper understanding of its metropolitan impacts, once it is expanding also to suburban areas, multiplying its presence across the metropolis borders and creating sub-processes of gentrification (Cortez, 2023) by relocating people to suburban areas (Corte-Real et al., 2021).

Within this context, the Setúbal Peninsula, located in the southern bank of the Tagus River, has emerged as an attractive alternative for those seeking to live near the capital while benefiting from better urban livability without giving up proximity to Lisbon (Louro, et al., 2021). However, the increasing population in these areas places additional pressure on local infrastructure, public services, and housing availability (Silva, 2022), extending the cycle of urban transformation and imposing challenges to urban livability in these suburban cities, generating a cascading gentrification effect (Cortez, 2023). If, on one hand, these areas usually offer more affordable rents and better housing conditions (Harris, 2015), on the other hand, their infrastructures have not yet been fully prepared to absorb this population increase, resulting in overcrowded public transportation, pressure on urban services, and a new dynamic of real estate speculation.

Despite previous research and existing literature having explored this phenomenon and the impacts of gentrification and displacement in the city of Lisbon itself, as the most important Portuguese metropolis (Thomas, 2024; Estevens et al., 2023; Mendes, 2023; Heinermann, 2022; Cocola-Gant & Gago, 2021; Nofre & Sequera, 2019;), a research gap persists in understanding the specific impacts of these phenomena in the urban livability of the southern suburban area of the metropolis. More specifically, the gap falls upon understanding how gentrification-driven pressures originating in the capital may be shaping and influencing the demographic dynamics of the Setúbal Peninsula, and how to strategically measure and display the region's key demographic indicators to foresight upcoming infrastructural pressures.

Given the gentrification phenomena and its inherent impacts in the Setúbal Peninsula, the research question is: *To what extent are the demographic trends in the Setúbal Peninsula being affected by Lisbon's gentrification, and how can this spillover effect be measured*

through demographic indicators? Thus, the research will focus on the following specific objectives: i) assess the current demographic structure and evolution of the Setúbal Peninsula, analyzing key indicators such as population growth, age distribution, dependency ratios, and population renewal; ii) define and develop key performance indicators (KPIs) based on demographic data, including population ageing, youth ratios, and active population dynamics, to quantitatively measure structural changes potentially driven by spillover pressures; iii) conduct a foresight analysis to project the region's population up to 2041, considering three different scenarios (optimistic, moderate, pessimistic), aiming to compare possible future demographic shifts and their implications for regional planning and urban livability.

In order to accomplish the established goals, this research will follow the Design Science Research Methodology (DSRM), aiming to develop an analytical system (Peppers et al. 2007) for assessing the research problem. The research will be based on the DSRM framework, including problem identification and motivation, the definition of objectives for a solution and the design and development of an artifact, followed by its demonstration and evaluation (vom Brocke et al., 2020). The core artifact of this research will be a Business Intelligence (BI) model, which shall integrate historical demographic data and the demographic projections to measure key performance indicators (KPIs) related to the research topic.

Demographic data will be retrieved from official sources and used as an input for both descriptive and foresight analysis, aiming to project future scenarios through the cohort-component method (Bravo et al., 2018). This method is expected to estimate three population growth scenarios by 2041, incorporating multiple demographic components to assess how the ongoing process of gentrification in Lisbon may affect the region's demography, infrastructures and livability. The Business Intelligence (BI) model will be developed recurring to the Microsoft Fabric environment, allowing structured data storage in a Data Warehouse, following the core principles of dimensional modeling (Kimball & Ross, 2013). Power BI will be mainstream for data visualization and reporting, transforming raw data into actionable information that highlights the mentioned demographic trends.

Through the development of this system, the research is expected not only to provide an interactive assessment of key indicators, but also to produce a decision-making support artifact, allowing a comprehensive analysis of demographic trends in the region as a result of the spillover effect of Lisbon's gentrification, and how it is expected to shape infrastructural needs within the Setúbal Peninsula up to 2041. The final artifact intends to be a tool for public policy urban planning, both at a local, municipality-level, and macro, metropolitan-level, considering that Lisbon city hosts a significant percentage of the national population (INE, 2025), and that this percentage is not expected to decline in the next fifteen years, but rather redistribute spatially, particularly to the southern bank of the Tagus River, when considering the main findings of this research. Thus, the model aims to provide support for data-driven decision making (Hjelle et al., 2024; Matheus et al., 2020), guiding urban planning policies in the region and enabling an assessment of both ongoing and upcoming challenges.

2. LITERATURE REVIEW

2.1. URBAN DYNAMICS, SUBURBANIZATION AND URBAN LIVABILITY

Even though this phenomena is not completely new, in the past decades, the urban centers have seen a fast and high-volumed increase in their population density (Soares et al., 2022), which is mostly driven by multiple factors such as better professional and academic opportunities, increased access to cultural activities, and also increased availability of goods and services, all of which have led to a growing desire (Figueiredo, 2022) and need for people to live in or, at least, near these areas.

However, and despite the multiple benefits offered by these urban centers, this fast population growth has been leading to significant challenges, since the excessive population puts constraints on existing resources (Chen, 2022), as demand continues to rise, while supply remains limited. This dynamics creates pressures across various sectors and components of the main big cities and their respective metropolitan areas, such as housing, sanitation, energy, accessibility, and public transport networks. In this context, territorial policies must be designed in an integrated way, aiming to address the challenges posed by this urban environment. According to Louro et al. (2021), a livable metropolis should not only be functional, but also cater to the needs of its residents, fostering both development and integration between the community and the city's physical space.

2.1.1. THE SUBURBANIZATION PHENOMENON

In response to these increasing pressures on urban metropolis centers, suburbanization has become a prominent phenomenon, as the big cities are becoming more congested, leading to a natural expansion and shift of population to their borders, and engaging a spillover of the economic activity into their surroundings. In the concept of Harris (2015), suburbanization shall be seen as a movement of populations from central urban areas to the peripheries, driven by factors such as urbanization, improved transportation, job decentralization, and public policies. Given that, suburban areas provide an immediate and logical solution to overcrowding, offering more affordable housing and a higher quality of life in terms of space and environmental conditions, for those seeking to reside near the capital while benefiting from better urban livability without giving up proximity to the metropolis (Louro et al, 2021).

For Harris (2015), suburbanization becomes necessary to alleviate housing shortages and reduce urban congestion, but it also comes with a high cost, especially in terms of infrastructure development and environmental impacts. From an infrastructural perspective, the populational growth on suburban areas imposes direct implications for public services and infrastructure, placing pressure on transportation networks, energy distribution, public health systems, housing availability and accessibility (Harris, 2015). Facing this, it requires substantial investments that might be difficult for local governments to provide. Thus, the expansion of

the metropolitan area is rarely accompanied by strategic and integrated urban planning, leading to potential inefficiencies that replicate the lack of services and amenities found in central urban areas (Soares et al., 2022).

As cities continue to expand in a fast rhythm (Soares et al., 2022) into suburban areas, and also through urban intensification, it becomes even more mainstream that urban planning shall incorporate the needs of both central urban areas and the suburbs to create more sustainable, inclusive, and livable cities. Thus, suburbanization must be easily seen as an actual worldwide phenomenon, taking place in almost every metropolis in the world (Corte-Real et al., 2021) nowadays. Given this, the phenomenon requires more strategic management to balance both its benefits with its potential long-term impacts.

2.1.2. SUSTAINABLE DEVELOPMENT AND URBAN LIVABILITY

First introduced by the United Nations' World Commission on Environment and Development (1987) Brundtland Report, the concept of sustainable development has been quite influential across the years, used for urban planning strategies in different regions. The main focus of sustainable development is to align the urban development with infrastructural systems that are able to address the challenge of providing accessibility to urban features, while simultaneously reducing environmental impacts, ensuring quality of life.

Despite being an important concept, the main concern of sustainability is achieving long-term goals, paving the way for future demands. However, it is important to acknowledge that the urban phenomenon is a dynamic concept (Sforna, 2022), and with that, comes the need to achieve short-term, real-time goals, in order to really ensure quality of life in most of urban centers. Alongside with sustainability, the concept of urban livability arises (Louro et al. 2021), most related with the capability of a given urban space to achieve immediate effects in meeting the urban needs of the residing community. However, the very concept of urban livability is quite debatable, being also highly subjective as livability might mean different things to different people (Louro, et al. 2021), depending, mostly, on their priorities.

Kim, Sabri and Kent (2021) make a bridge between the urban livability and the smart city concepts, as livability might be seen as one of three fundamental objectives of smart cities, alongside productivity and sustainability. Firstly, productivity in smart cities is often driven by technological advancements, which helps reducing costs and increasing benefits on citizens' daily routines. Sustainability, on the other hand, is supported by technological solutions that are able to optimize resource usage, which lead both people and the environment to benefit. However, livability is a main focus since it interests all stakeholders in a specific city, from its residents to urban public policies planners. Despite not having a solid concept, livability is characterized by Kim et al. (2021) within factors as safety, walkability, public services, and access to public facilities, transportation and natural spaces. Given these indicators, technology plays a crucial role in enhancing all these subsectors of cities. However, its success

depends on identifying citizens' needs and prioritizing them as the primary beneficiaries of technological advancements, ensuring that every smart city initiative serves societal needs first.

Chen (2022) also brings an interesting perspective on urban livability, associating the concept with subjective well-being by determining that, by the most important the physical infrastructure might be in the context of livability, it is deeply connected to the citizens' perception of happiness and quality of life. When urban planning, Chen (2022) attests that considering the citizen's happiness is paramount, since it directly reflects the city livability and its residents' lifestyles, converging with Louro et al. (2021) on the subjectivity of the concept. Engaging with Kim et al. (2021), Chen (2022) also considers that livability concerns objective indicators, such as occupation, housing affordability and urban security. Since livability is highly subjective, it is also highly dependent on historical and cultural backgrounds, which when explored, allow us to better understand local citizen's needs and perceptions.

Schindler and Dionisio (2024) also point out urban livability as a two-faced concept, interconnecting both social and spatial dimensions, engaging with Chen (2022) when attesting that an area's physical environment is directly linked to the social experiences and perspectives of its inhabitants. Urban livability is achieved through the positive merging between diverse community demands and aspirations, and the city capability of providing tools to fulfill these demands. The main goal, according to the authors, is to improve the socio-spatial outcomes by ensuring access to essential resources and reducing local vulnerabilities. In a very similar way to the past two authors, Schindler and Dionisio (2024) call out for Newton's (2012) definition of urban livability, which is seeing as "*those attributes of a place that contribute to quality of life and wellbeing*", converging to the connection between livability and quality of life.

Given the multidimensional nature of the urban livability concept, it is common sense in literature that a universally accepted conceptual framework is still lacking, making the concept very subjective and adaptable to different sociocultural contexts, which can be seen as a research advantage. However, it is also a consensus that, even though urban livability is mostly perceived by qualitative analysis on citizen's perceptions, it can also be measured through objective and quantitative indicators (Khorrami et al. 2020; Kim et al., 2021; Louro et al., 2021; Chen, 2022; Schindler & Dionisio, 2024), some of them pointed out by more than one author. Regarding the measurement of urban livability indicators, Khorrami et al. (2020) performed a scoping review on the indicators and methods used for measuring urban livability, which, as mentioned in Louro et al. (2021), included sixty-seven articles regarding the topic, enabling the establishment of the most important indexes and methodologies for assessing urban livability in a quantitative way.

Lastly, Louro et al. (2021) adds great value to this research by transposing the concept of livability to a metropolitan level, which is particularly important when studying the impacts of Lisbon's gentrification on the Setúbal Peninsula livability. According to Louro et al. (2021), "*a*

livable metropolis is the unique, functionally linked urban form that responds to the human needs, scale and aspirations and promotes the integral development of the person while improving its relationship with the space, both built and natural". When transposing this concept to the metropolitan level, a metropolis can be seen in two ways: as a large, unified community, or as a system of interconnected communities, each with distinct characteristics. This thesis aligns with Louro et al. (2021) by supporting the latter approach, since the first one is insufficient to measure urban livability in the Setúbal Peninsula, formed by multiple smaller communities that, interconnected, composes the southern bank of the Lisbon Metropolitan Area.

2.2. THE GENTRIFICATION OF LISBON: A DRIVER FOR SUBURBANIZATION

2.2.1. THE URBAN AND SOCIAL PROCESS OF GENTRIFICATION

Not just a concept, gentrification is essentially an urban process of socio-spatial transformation occurring in urban centers, particularly in large and cosmopolitan metropolises. It involves a social substitution process directly correlated to the rehabilitation of urban areas in historic city centers (Glass, 1964), through both public and private investment policies. As a result, gentrification is characterized by the arrival of middle-class groups with higher economic power into previously devalued urban areas. Consequently, these areas gain social, economic, and environmental value, in a phenomenon named by Hall (1998) as a *filtering up* process (as cited in Mendes, 2023).

Hall's (1998) *filtering up* process consists, essentially, in a significant change in the social dynamics of the affected neighborhoods, where the rehabilitation of properties in working-class neighborhoods or those originating from lower-income classes leads to the attraction of wealthier residents (Mendes, 2023), aiming to establish residence in these renewed areas, or to make housing investments in order to take advantage of better real estate market's opportunities (Estevens et al., 2023). This results in the displacement of the former residents to other areas, driven by their inability to afford not only the higher housing costs arising from urban regeneration, but also the increased cost of living. Since *filtering up* involves a shift in the social paradigm on multiple levels, it directly impacts the level of urban livability of these communities. In other words, the former residents find themselves surrounded by rising costs imposed on them, with no option but to seek more affordable areas to settle.

In line with this definition, it is important to refer to the perspective of Savage and Warde (1993) on the process of gentrification. In the authors' perspective, gentrification extends itself way beyond economic and demographic aspects, being more of a sociocultural phenomenon. Thus, gentrification is not seen just as a spatial transformation in the city centers, but as a bigger issue, involving complex interactions between different social classes, culture and power. Gentrification is essentially a social substitution process (Savage & Ward, 1993), which leads to a redefinition of the power dynamics among groups living in a given

urban area. In their perspective, as upper-classes move into lower-classes neighborhoods, these zones cease to be marked by the former residents' identity and feeling of belonging, becoming more homogeneous social spaces, aligned with the interests of this new occupying class.

This alters the local population's relationship with the neighborhood and renews the dynamics of dominance and power. To Savage and Warde (1993), the phenomenon is also related to a shift in lifestyles and local cultures, as groups with consumption patterns and lifestyles aligned with middle-class interests move into an area, modifying not only the physical environment but also the social behavior and cultural dynamics of the space, which creates a cultural homogenization where the practices and tastes of the new residents prevail over those of the former inhabitants, reinforcing, once again, the renewed dynamics of power and dominance.

Additionally, Savage and Warde (1993) engage with Esteves (2023) and Cocola-Gant and Gago (2021) when discussing the relationship between gentrification, urban public policies, and the real estate market. Through state intervention, which include tax incentives, investments in infrastructure, and urban regeneration promotion, the most degraded or devalued areas of cities become attractive to private investments, and here, the real estate market acts as a driver for rising property prices and area renovation. This scenario creates conditions for wealthier residents to move in and push out the former inhabitants, as the gentrification process is accompanied by social exclusion and the marginalization of certain groups, who might be pushed to the city's peripheries, since remaining in the center becomes unfeasible. Thus, the public interventions produce contradictory effects, becoming even paradoxical, according to Mendes (2023) and Esteves (2023): aimed at urban valorization, with promises of attracting investments in order to improve the city, they end up resulting, mostly, in the displacement of that area's residents, empowering a process of exclusion.

2.2.2. THE GENTRIFICATION AND TOURISTIFICATION OF LISBON

Throughout the last decade, the city of Lisbon has been going through an intensive process of gentrification and *touristification* (Mendes, 2023), which as consequence has led to displacement, social segregation, and the reshaping of the city's urban life, directly affecting the urban livability in the whole region, including Lisbon Metropolitan Area and, as a main part of it, the Setúbal Peninsula, which is the geographical area this research focuses on.

Alongside with this *touristification* (Mendes, 2023) process, the Portuguese capital has also become a focus target for real estate investors, some local, but mostly foreign, which triggered a housing rehabilitation wave in the city's historical center (Esteves et al., 2023). However, it is important to acknowledge that this process did not occur in a vacuum, but rather was encouraged and sponsored by public policies designed to position Lisbon on the global stage (Cocola-Gant & Gago, 2021), which, through that, promoted the influx of external capital, promoting the gradual conversion of urban infrastructures into tourism-driven

accommodations. Given that, Estevens et al. (2023) points out to the idea that this uncontrolled expansion of housing for tourism finalities could not have taken place without direct state intervention, which closely aligns with what Nofre and Sequera (2019) define as *state-led touristification*, with public policies actively contributing to the transformation of urban space in favor of tourism and global investment.

This restructuring is deeply connected to a historical process in which the Mediterranean Europe has become, more often, a prime tourist destination (Thomas, 2024), due to its favorable climate and relatively affordable costs for foreign visitors. However, as this transformation aligns with Savage & Warde's (1993) concept of gentrification, it reinforces a dynamic of prioritizing transnational and transient populations, such as tourists and digital nomads, over long-term residents, and the entering of tourism into formerly residential areas has, naturally, accelerated displacement, gradually replacing traditional communities (Antunes & Seixas, 2019) with temporary populations that often have greater financial means, the *gentry*¹, as defined by Glass (1964).

Thus, a key factor driving gentrification is, as previously studied by different authors (Mendes, 2023; Estevens et al., 2023; Heineremann, 2022; Cocola-Gant & Gago, 2021; Nofre & Sequera, 2019) the former liberalization of the housing and rental markets, alongside with urban rehabilitation policies and the rapid expansion of tourism, generating the gradual "*airbnbization*" (Nofre & Sequera, 2019) of the city. With the absorption of most redevelopment costs by the Portuguese state, the private capital found the space needed for profiting with these rehabilitations and most important, with reduced regulatory constraints, leading to, consequently, the proliferation of profit-focused urban developments (Estevens et al., 2023).

These dynamics have contributed to, and as usual gentrification processes, the displacement of long-term residents, increasing of living costs, and profound shifts in the sociocultural fabric of the affected neighborhoods (Mendes, 2023). As tourism was firstly seen as a national strategy for urban growth, Lisbon's housing market has increasingly catered to global investment rather than local needs (Cocola-Gant & Gago, 2021), hardly affecting the balance between economic development, housing affordability, and urban livability in the Portuguese capital.

The impacts of this dynamic become even more evident when comparing demographic data from the 2011 census with the most recent one from 2021, in which Lisbon recorded a -1.25% population variation rate, marking the second-largest population decline in the Lisbon Metropolitan Area, surpassed only by Amadora, with a rate of -2,10%. (INE, 2025).

¹ The term *gentry* refers to the upper-middle or upper class that, in the process of gentrification, replaces lower-income populations in certain urban areas. These individuals, typically with higher purchasing power, education levels, and lifestyles aligned with modern urban consumption dynamics, contribute to transforming neighborhoods previously occupied by lower-income communities.

2.2.3. THE IMPACTS OF LISBON'S GENTRIFICATION ON THE SETÚBAL PENINSULA

While much attention is given to gentrification and the rising cost of living as key drivers of this exodus, there is little discussion about where these displaced residents actually go. According to Silva (2022) and Figueiredo (2022), the classic gentrification concept is nowadays facing a change in terms of coverage. If once it was focused on real estate dynamics and population substitution in the metropolis centers, now it must be observed with a deeper understanding of its metropolitan impacts, once it is expanding also to suburban areas, multiplying its presence across the metropolis borders, and creating sub-processes of gentrification. In line with that, Corte-Real et al. (2021) points out that Lisbon's process of *touristification* not only act as a driving force to long-term residents' displacement, but also help relocating them to suburban areas, consequently reshaping the geographic and social landscape of the Lisbon Metropolitan Area.

In a recall to the 2021 Census results, it is important to mention that, as Lisbon has lost a significant portion of its resident population, all municipalities on the southern bank of the Tagus River, with exception of Barreiro, have experienced population growth (INE, 2025), suggesting a possible direct correlation between Lisbon's gentrification and its suburbanization, driving a demographic shift toward the Setúbal Peninsula. However, and aligning to Silva (2022), the increasing population in these areas places additional pressure on local infrastructure, public services, and housing availability, extending the cycle of urban transformation and displacement and imposing challenges to urban livability in these suburban cities.

The population displacement of Lisbon residents, as well as new inhabitants moving to the region from other locations, generates a cascading gentrification effect (Cortez, 2023). If, on one hand, these areas usually offer more affordable rents and better housing conditions, on the other hand, their infrastructures have not yet been fully prepared to absorb this population increase, as anticipated by the Setúbal Peninsula Strategic Development Plan for 2020 (2014). This situation results in overcrowded public transportation, pressure on urban services, and a new dynamic of real estate speculation in these cities (Silva, 2022). Therefore, this population redirection has aligned with Neil Smith's (1996) concept of *frontier of gentrification*² (as cited in Mendes, 2023), in which real estate capital, having exhausted opportunities in central areas, expands its reach into new urban frontiers, leading to a subprocess of gentrification in these cities. The growing demand for housing causes prices to rise, reducing affordable housing options and, gradually, expanding the dimension of the problem.

Aiming on studying the relationship between urban development and gentrification, Thomas (2024) conducts a case study on the city of Lisbon, examining the historical and economic

² Smith's concept of the *frontier of gentrification* highlights how urban development processes push outward from core areas into the peripheries, creating new cycles of displacement and urban transformation.

development of Lisbon in order to investigate the gentrification process in the city, identify its main causes and analyze its consequences, trying also to explore potential strategies to mitigate its effects. Seeking to achieve these goals, the case study takes into consideration demographic data retrieved from the Portuguese National Institute of Statistics (INE), and data concerning real estate speculation, evolution of rental and purchase prices across different neighborhoods, and other relevant indicators that contribute to a better understanding of the progression of gentrification in Lisbon.

On the other hand, Cortez (2023) presents an even narrower study, focusing on the sub-process of gentrification occurring in Almada, which is the closest city to Lisbon on the southern bank. For the author's case study, Cortez (2023) used both qualitative methods, such as interviews with local residents, and a quantitative approach based on statistical data, also retrieved from INE, which included available data on tourism and housing costs over the past decade, in a metropolitan scale. This mixed-methods approach allowed to frame the gentrification process occurring in Almada, which is a smaller spectrum of the phenomenon that is taking place in the whole region.

Thus, both Thomas (2024) and Cortez (2023) relied on quantitative data from official sources to quantitatively demonstrate the occurrence of the gentrification process in Lisbon. However, while Thomas (2024), just like Estevens (2023), Mendes (2023), Heineremann (2022) and Cocola-Gant and Gago (2021), focuses on the city of Lisbon itself, Cortez (2023) stands out by analyzing the sub-process of gentrification in one of the cities of the Setúbal Peninsula, which opens the possibility for analyzing sub-processes across the entire region, extrapolating the case of Almada to the broader Peninsula and complementing Smith's (1996) thesis on the frontier of gentrification (Silva, 2022; Corte-Real et al. 2021; Xerez, 2008).

Additionally, the work of Louro et al. (2021) must be highlighted, since it closely aligns with the objectives of this research. Even though indirectly, because Louro et al.'s work focuses mostly on urban mobility within the LMA, the authors were able to connect gentrification with urban livability, while also presenting a robust framework for measuring urban livability indicators, from local to metropolitan scales. Similar to Thomas (2024) and Cortez (2023), Louro et al. (2021) also relied on official data from INE to reveal intra-metropolitan differences within the LMA urban mobility.

Considering the geographical focus of Louro et al. (2021), basing the study within the LMA, the authors highlight the significant transformations the LMA has undergone in recent years. Also based on the 2011 Census, their data shows that Lisbon lost inhabitants to adjacent suburban areas, and between 1981 and 2011, the highest population growth occurred on the south side of the Tagus River, as Lisbon city experienced a huge decline in residents while suburban areas, simultaneously, expanded. When comparing these trends with data from the 2021 Census previously mentioned, it is evident that the trend persists, underscoring the importance of forecasting these demographic shifts to better prepare for the impacts of gentrification and its expanding boundaries (Smith, 1996) into the suburban areas.

2.3. DATA-DRIVEN URBAN PLANNING

2.3.1. SMART CITIES: A SMARTER WAY OF URBAN PLANNING

Despite the fact that there is no universal definition of smart cities, Lazzaretti et al. (2019) points out what could even be considered a consensus when considering their main goal and objectives, which are, in a very summarized way, optimizing the use of public resources and enhancing the quality of services provided to citizens, while reducing operational costs for public administration. Neirrotti et al. (2014) (as cited in Lazzaretti et al. 2019) adds the idea that the evolutionary patterns of smart cities are dependent on local contextual factors, including natural resources and energy, transportation and mobility, buildings, living conditions, governance, economy, and people.

Nonetheless, it is also possible to adopt the European Commission definition of smart city as a starting point, once it is defined as *“a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business [...] it means smarter urban transport networks, upgraded water supply and waste disposal facilities and more efficient ways to light and heat buildings. It also means a more interactive and responsive city administration, safer public spaces and meeting the needs of an ageing population.”*

Sforna (2022), when presenting her study on the role of Public Administration as a planner in the development of smart cities, suggests that the terminology *smart* has increasingly been associated with cities and urban environments, in the past decades, which are driven by urban transformation as a result of technological advancements. The author also mentions a study conducted by the Vienna University of Technology, in which a smart city might be defined as *“a city well performing in a forward-looking way across six characteristics – smart economy, smart people, smart governance, smart mobility, smart environment, and smart living – built on the ‘smart’ combination of endowments and activities of self-decisive, independent, and aware citizens”*, highlighting their multidimensional nature.

Closely aligned with the UN 2030 Agenda for Sustainable Development, which emphasizes the need to enhance urbanization and urban planning to ensure inclusive, safe, resilient, and sustainable cities, these definitions allow us to align with Schindler and Dionisio (2024), Soares et al. (2022) and Chen (2022) when considering that smart cities emerge as a way to address urban challenges by leveraging technology to provide tools for more efficient resource management. However, Soares et al. (2022) study emphasizes that technology alone is insufficient to solve urban issues, and it must be integrated with urban planning, which engages with Sforna’s (2022) point of view.

Smart cities are not to be a final goal but more a mean to achieve public policies goals (Soares et al., 2022). The Public Administrations, as key players in the process of transformation and development of the cities (Sforna, 2022), may enhance decision-making by fostering collective intelligence, as citizens are often the most knowledgeable about their own needs and daily

challenges (Soares et al., 2022), which allows a truly data-driven governance. A citizen-centered approach, aligned with advanced technology solutions and methodologies, represents a huge opportunity for governments to improve their urban planning performances, reaching out to the citizens' necessities and implementing solutions that will properly address these challenges.

2.3.2. BUSINESS INTELLIGENCE AND DATA-DRIVEN DECISION MAKING

The fast and increasingly complex growth of urban centers, alongside with the swift transformation of nowadays cities (Soares et al., 2022), demands more assertive, informed, and transparent decision-making in the formulation of public policies. Within the context of urban planning, data-driven decision-making is a fundamental aspect to address emerging and evolving challenges, and particularly those related to the demographic dynamics. Considering this scenario, the analytical tools based on data analysis have proven to be powerful instruments, not only in this domain, but also in reshaping how decisions are made across both public and private organizations.

The growing wave of analytics tools' adoption in order to support decision-making is related to the pressing need to make informed and accurate choices in a world where information proliferates fast, in great volumes, and under highly competitiveness (Hjelle et al., 2024). Nowadays, and given this context, decision-making in an information vacuum is no longer viable, and instead, easy and intuitive access to relevant data is key for guiding strategic planning pathways. Resulting from this phenomena, there is increasing interest rising from different stakeholders in understanding how the design and use of data visualizations can enhance decision-making quality, and as so, Business Intelligence (BI) tools are emerging as key value-adding technologies in these scenarios.

Regarding the public policies domain, data-driven decision-making enables more strategic, informed and participative urban planning. According to Matheus et al. (2020), data dashboards, throughout the integration of multiple sources of information, offer a clear and accessible view of the current state of cities, being particularly valuable for analyzing demographic trends, visualizing future projections, and fostering a forward-looking approach (Rodrigues, 2024). This type of approach facilitates early identification of pressures on public infrastructure and services, while also promoting a data-driven culture within public administration and, in doing so, it acts as a catalyst for digital transformation at both micro and macro levels of public governance, contributing to the development of more resilient and sustainable cities over the long term.

Considering the integrated Business Intelligence systems and end-to-end solutions, such as the one proposed in this study, these tools provide not only a clear and intuitive understanding of demographic dynamics, but also enable the obtaining of insights into potential future populational behaviors. Thus, if such systems were available in key political decision-making

offices, it would mean a significant step toward truly data-driven urban planning (Hjelle et al., 2024; Rodrigues, 2024; Soares et al., 2022; Matheus et al., 2020), and that is something that inspires the development of this study.

Presented by Soares et al. (2022), the “Nós Sesimbra” initiative exemplifies in practice the benefits of implementing these types of technological solutions. The initiative introduced an application allowing citizens to report urban issues in multiple categories, helping to collaboratively address municipal infrastructure challenges. By collecting crowdsourced data, the study highlighted, of course, the importance of data integration, analysis, and reporting for effective urban management, while also emphasizing that citizens' needs must remain central. Based on the data collected, the study proposes a Business Intelligence (BI) solution to facilitate real-time decision-making and data-driven policy development, ensuring that stakeholders fully understand the Key Performance Indicators (KPI) significance and application. Thus, the “Nós Sesimbra” serves as a relevant case study, demonstrating how local governments can implement smart city strategies – and specifically BI methodologies – to address urban challenges, closely aligning with the methodology that is proposed in this study.

3. DATA AND METHODOLOGIES

3.1. DESIGN SCIENCE RESEARCH METHODOLOGY (DSRM)

As previously mentioned, and aiming to accomplish the established goals, the research follows the Design Science Research Methodology (DSRM), proposing to develop an analytical system (Peppers et al. 2007) for assessing the spillover effects of Lisbon's gentrification in the Setúbal Peninsula's demographic trends.

As outlined by vom Brocke et al. (2020), DSRM consists in a problem-solving paradigm, seeking to enhance human knowledge through the development of innovative artifacts that represent solutions to real-world problems, and as so, it is a very structured approach, which aims to create innovative solutions, that are therefore rigorously tested and properly evaluated (Peppers et al. 2007).

Within the context of this research, this methodological framework was considered particularly well-suited, since it helps bridging the existing gap between theoretical understanding and practical application by focusing on addressing real-world challenges through the development and implementation of innovative artifacts, such as the proposed BI solution. Thus, DSRM is highly applicable in the field of urban studies, where the research is expected to produce solutions for urban matters that can be tested, used and, if needed, refined.

Aligning with the research context, DSRM connects well with the research goals, enabling the development of a Business Intelligence (BI) model that integrates historical demographic data and the demographic projections to assess the spillover effects of Lisbon's gentrification. The methodology ensures that the model is systematically designed, tested, and evaluated against real-world data, and being an iterative and adaptable methodology, it is open for continuous refinement, ensuring that it remains relevant as the demographic trends keep changing through time.

According to vom Brocke et al. (2020), the most widely referenced DSRM Process Model is the one proposed by Peppers et al. (2007), which includes six sequential steps (Figure 1): **i) problem identification and motivation**, which involves clearly defining the research problem, understanding the gap in existing knowledge and the significance of solving it; **ii) definition of objectives for a solution**, which involves outlining what an ideal solution should achieve, informed by both the problem definition and the literature review, serving as a benchmark for evaluating the success of the developed artifact; **iii) design and development**, which involves the actual creation of the artifact, guided by the problem's context, existing knowledge, and theoretical foundations; **iv) demonstration**, which involves applying the artifact in a real or simulated environment to demonstrate its utility; **v) evaluation**, which involves assessing how well the artifact solves the problem, based on the previously defined objectives; and **vi) communication**, which consists in the presentation of the findings to relevant stakeholders,

ensuring that the new knowledge and solutions developed through the research are accessible and can be applied in practice.

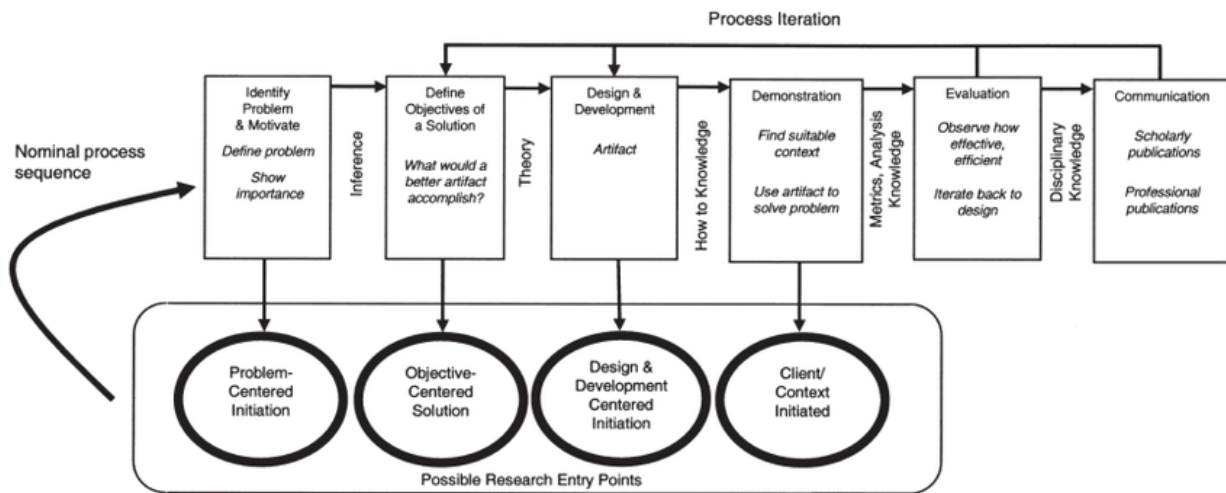


Figure 3.1 – DSRM Process Model (Peppers et al., 2007)

Following this model, the core artifact of this research is a Business Intelligence (BI) model that integrates historical demographic data and the demographic projections to assess the spillover effects of Lisbon’s gentrification in the Setúbal Peninsula’s demography.

3.1.1. PROBLEM IDENTIFICATION AND MOTIVATION

As mentioned, the city of Lisbon has been undergoing an intensive process of gentrification, which has contributed to the displacement of long-term residents and increased living costs, hardly affecting the balance between economic development and overall urban livability in the Portuguese capital. However, if the gentrification concept was once exclusively focused on the metropolis, now it must be observed with a deeper understanding of its metropolitan impacts, once it is expanding also to suburban areas, multiplying its presence across the metropolis borders and creating sub-processes of gentrification in suburban areas. The population displacement towards the Setúbal Peninsula cities might generate a cascading gentrification effect, and if, on one hand, these areas usually offer better and more affordable housing conditions, on the other hand, their infrastructures have not yet been fully prepared to absorb this population increase, resulting in overcrowding and infrastructural pressures, gradually expanding the problem’s dimension.

Despite previous research and existing literature having explored this concern and the impacts of gentrification and displacement in the city of Lisbon itself, a research gap persists in understanding the specific impacts of these phenomena in the urban livability of the southern suburban area of the metropolis. More specifically, the gap falls upon understanding how gentrification-driven pressures originating in the capital may be shaping and influencing the

demographic dynamics of the Setúbal Peninsula, and how to strategically measure and display the region's key demographic indicators to foresight upcoming infrastructural pressures.

This issue demands an analytical approach that integrates demographic data to systematically assess, measure, and anticipate the mentioned effects, and addressing this gap is essential for a better urban planning, implementing a data-driven solution that might mitigate populational constraints and improve overall urban livability in the studied region.

3.1.2. DEFINE OBJECTIVES FOR A SOLUTION

Given the gentrification phenomena and its inherent impacts in the Setúbal Peninsula, the research question is: *To what extent are the demographic trends in the Setúbal Peninsula being affected by Lisbon's gentrification, and how can this spillover effect be measured through demographic indicators?"*.

Thus, the research focuses on the following specific objectives:

1. Assess the current demographic structure and evolution of the Setúbal Peninsula, analyzing key indicators such as population growth, age distribution, dependency ratios, and population renewal.
2. Define and develop key performance indicators (KPIs) based on demographic data, including population ageing, youth ratios, and active population dynamics, to quantitatively measure structural changes potentially driven by spillover pressures.
3. Conduct a foresight analysis to project the region's population up to 2041, considering three different scenarios (optimistic, moderate, pessimistic), aiming to compare possible future demographic shifts and their implications for regional planning and urban livability.

To address these objectives, demographic data will be retrieved from official sources and used as an input for both descriptive and foresight analysis, aiming to project future scenarios through the cohort-component method. This method is expected to estimate three population growth scenarios until 2041, incorporating multiple demographic components to assess how the ongoing process of gentrification in Lisbon may affect the region's demography, infrastructures and livability. Additionally, an interactive dashboard will be developed to properly display the information.

3.1.3. DESIGN & DEVELOPMENT

In the Design & Development phase of the research, a Business Intelligence (BI) model will be designed and implemented recurring to the Microsoft Fabric environment, making use of a

structured data architecture to ensure the proper efficiency and analytical depth needed. Thus, the core artifact developed in this research will be an end-to-end BI solution, covering the entire data workflow, from the raw data to the relevant insights shown through an interactive dashboard, which will provide an analytical approach on the demographic evolution in the Setúbal Peninsula as a consequence of Lisbon's gentrification spillover effects, thus, providing an answer to the research question. The solution follows a layered approach, integrating different Microsoft Fabric components for data ingestion, transformation, storage, and visualization, guided by design principles and best practices in data engineering and BI modeling. This phase will be deeper explored in a further dedicated chapter.

3.1.4. DEMONSTRATION

Through the development of this system, the research is expected to provide an interactive assessment of key indicators, providing a comprehensive analysis of projected demographic trends in the region as a result of the spillover effect of Lisbon's gentrification, and how it is expected to shape Setúbal Peninsula's demographic reality up to 2041, allowing an assessment of both ongoing and upcoming challenges.

Since the BI solution will be demonstrated using real-world demographic data, it is intended to allow the comparison between current and projected indicators. In simple terms, the objective of producing this artifact is to allow the visualization of the projections made through the cohort-component method, aiming to establish and assess possible correlations between Lisbon's gentrification and the demographic shifts in the Setúbal Peninsula, providing an analytical tool to answer the research question and accomplish the research objectives.

3.1.5. EVALUATION

In the Evaluation phase, the developed BI solution will be assessed based on its effectiveness in properly addressing the research problem, which means the developed KPIs must be reliable and properly reflect the real-world trends regarding the research topic. For that, the usability and meaningfulness of the dashboard will be tested to determine how well the model is capturing and highlighting the demographic trends in the region, since the artifact is designed to answer real-world problems and, by that, it must deliver valuable insights.

To ensure the desired reliability and validity of the proposed BI model, its evaluation approach will be based on a particular assessment criterion, since the primary objective is to determine whether the developed artifact effectively addresses the research question and objectives while ensuring usability and robustness in its outputs. To evaluate the alignment of the artifact with the proposed research question, the model's output will be assessed in relation to the specific research objectives: i) assessing current demographic structure and evolution of the Setúbal Peninsula: does the model accurately capture these trends and provides a clear

visualization of the predicted scenarios, allowing for comparison and evolution analysis? ii) defining and developing KPIs: are the selected KPIs effective in quantitatively measuring structural changes driven by spillover pressures? iii) conducting a foresight analysis for 2041: does the predictive component effectively project future demographic trends and different scenarios? To answer these assumptions and properly address the success of the artifact, the accomplishment of these objectives will be qualitatively and quantitatively reviewed through real-world data comparison and by revisiting related studies pointed out in the literature review.

The proper nature of the DSRM methodology framework is iterative, which ensures that the model is systematically designed, demonstrated and evaluated against real-world data, and being an iterative and adaptable methodology, it is open for continuous refinement, ensuring that it remains relevant and adaptable.

3.1.6. COMMUNICATION

Lastly, the final phase of this research focuses on effectively disseminating the main findings and the results provided by the final BI solution to the target audience and main stakeholders through the academic publication of the research, alongside with the solution's reports and interactive dashboards, ensuring accessibility and usability for all interested parts. The main goal to achieve is providing to the broad scientific community a data-driven approach to understand and, when possible, mitigate the demographic challenges caused by Lisbon's gentrification spillover effects in the Setúbal Peninsula.

Thus, the primary objective of this phase is to properly share the knowledge obtained through the creation of the artifact, providing a data-driven framework that enhances the understanding of the studied topic and represent solutions to real-world problems. Also, another underlying principle of this research is to make all the insights and information gathered from the research outputs accessible to the academic community, supporting evidence-based decisions and contributing to other studies in the field.

The dissemination strategy adopted in the Communication phase aligns with the DSRM framework (Peffer et al., 2007; vom Brocke et al., 2020), since it ensures that the research findings are not only in the theoretical spectrum, but also practically applicable, serving as a potential reference for further research and delivering a practical decision-support tool that may, somehow, influence urban policies and strategies to enhance urban livability in the Setúbal Peninsula, given the continuous impacts of the gentrification sub-process in the region.

3.2. RESEARCH METHODS AND DATA COLLECTION

3.2.1. RESEARCH METHODS

This research has a particular nature, since it goes through a quantitative approach on the gentrification process, by designing an artifact to properly measure demographic indicators through a Business Intelligence methodology, but also has a qualitative component on the social spectrum of the subject, which is well highlighted in the literature review and is used as a guideline for properly understanding the results. In other words, the qualitative component of this study is crucial for sustaining further data storytelling, when analyzing the results of the design stage of the DSRM methodology.

As might be concluded by the information so far provided, the gentrification phenomenon is deeply studied in social sciences (Mendes, 2023; Cocola-Gant & Gago, 2021), mostly because of its strong demographic component, which relates to socioeconomic factors, but also because of the social implications it carries, since the gentrification process and its spillover effects go way beyond urban economics, directly impacting the social structure and the power dynamics of affected communities (Hall, 1998; Smith, 1996; Savage & Warde, 1993). Firstly, the demographic shifts are core indicators in this research and are also main concerns of social sciences such as urban studies and human geography.

The suburbanization of Lisbon towards the Setúbal Peninsula due to the rising cost of living can be evaluated through a statistic and quantitative perspective, but it would be insufficient to provide a deeper understanding of the process, since this phenomenon affects urban livability in a social perspective as well, leading to the marginalization of populations and the reshaping of neighborhoods. Thus, quantitative analysis will provide information that will be useful for, and through social lens, understand the impacts of the phenomenon in a more robust way.

Given this nature, the research methods were chosen considering the multifaceted characteristic of the problem, allowing a broader understanding of the urban development patterns influenced by the gentrification process. Aiming to successfully address the defined objectives, this research adopted a mixed-methods approach, combining both quantitative and qualitative research methods.

The quantitative component of the research focuses on the collection, transformation, visualization and analysis of demographic data, including variables and KPIs that will be further explored. Also, and guided by the cohort-component method, the estimation of future population growth by 2041 allows a foresight analysis, going beyond descriptive analysis and providing the needed tools for a more prescriptive approach for the final users. These quantitative methods sustain the creation of KPIs that support a data-driven understanding of the spillover effects of Lisbon's gentrification on the Setúbal Peninsula, matching with the research objectives.

Although not at the core of the research, the qualitative component of the research consists in revisiting related studies pointed out in the literature review, which supports the interpretation of factors surrounding urban livability, useful for adding context to the analysis, since it explains the structural causes of suburbanization, enabling a broader understanding beyond only numerical data.

3.2.2. DATA TYPES

In the case of this research, the collected data is secondary, since it comprises the publicly available statistics and datasets regarding demographic data from the Portuguese official statistics institution, the *Instituto Nacional de Estatística* (INE). For the purposes of this research, the initial baseline population derives from the 2021 Portuguese Census data (INE, 2025), since it represents the most recent and comprehensive demographic assessment of the country. Conducted by INE, the Census provides the most accurate and detailed overview of the resident population, segmented by different possible attributes, allowing the creation of socioeconomic and demographic dimensions such as age groups and gender, which correspond to the cohorts for foresight analysis, but also date, location and other important dimensions to enrich the study. Because of its characteristics, this data is the most suitable input for the Cohort-Component Method, since it might be considered the most authoritative and stable reference for demographic projections, as it offers the most up-to-date and validated dataset on population distribution in Lisbon plus the Setúbal Peninsula.

By integrating all these datasets and adopting a mixed-methods approach within a single framework, the research enhances its own potential to produce a more robust model, that is simultaneously evidence-based, but also applicable to real-world problems when aligned with qualitative perspectives. This approach allows the final artifact to be useful, serving as a practical tool for visualizing the demographic shifts and projections in a quantitative perspective, but also supporting insights for academic purposes and policy formulation.

3.2.3. DATA COLLECTION METHODS

Considering the mixed-methods approach adopted in this research, the data collection strategy also followed a mixed structure. Firstly, the qualitative foundation was established through an extensive literature review, which, beyond supporting the identification of the research gap, provides theoretical and sociological grounding for the gentrification phenomenon, introducing the topic and justifying the relevance of the study. Additionally, as previously mentioned, this theoretical context is highly useful in the results analysis phase, since it serves as a theoretical benchmark to validate data accuracy and projection coherence based on what has been previously established in other academic research.

However, the emphasis of this strategy lies in the quantitative component, which is supported by reliable, official, and contextually relevant sources. Therefore, it is essential to collect as much statistical and demographic information as possible to support both a descriptive analysis of the current scenario and the population projection model based on the cohort-component method, as previously outlined.

Regarding data collection, the approach was based on retrieving demographic data from INE, which operates as a public body responsible for collecting, analyzing, and publishing official statistics on multiple aspects of the country's economy, population, society and development. One of INE's most important operations is the Census, a nationwide data collection effort typically conducted every ten years, and the most recent one was conducted in 2021, which is the baseline for this research.

It is important to highlight that other studies reviewed in the Literature Review (Thomas, 2024; Cortez, 2023; Louro et al., 2021) also relied on this source for quantitative data collection, due to its high reliability, comprehensiveness, and credibility in representing Portuguese demographic data. Among the studies mentioned, the methodology employed by Louro et al. (2021) for selecting data from INE's databases completely stands out, being an important and rigorous framework to be followed in the urban livability field. Louro et al. (2021) primarily relied on this data to reveal intra-metropolitan differences within the Lisbon Metropolitan Area (LMA), regarding urban mobility trends for multilevel planning. For their study, they selected only readily available data from official sources, following specific criteria. Based on the work of Louro et al. (2021), this research adopted the following criteria for demographic data collection:

1. The demographic data must be exclusively produced or gathered by official entities.
2. It must be fully available and accessible online, without financial constraints.
3. It must be regularly updated, in accordance with the quality and consistency standards of the official source.
4. It must be available for all municipalities within the Setúbal Peninsula, plus Lisbon, allowing for direct comparisons and preventing data gaps and potential biases.
5. It must be directly related to the research topic and useful for the demographic projections, avoiding the collection and storage of non-needed information.

Based on these criteria, the datasets obtained from INE's official website were manually downloaded in structured formats, which were CSV (.csv) or Excel (.xlsx), and subsequently imported into Microsoft SharePoint for storage, after applying the cohort-component method on the data. The datasets retrieved include the most recent population data collected in the 2021 Census, such as the number of residents by gender, age group, geographic location, as well as time-series demographic indicators like birth rates, mortality and migration patterns. All collected data was also subjected to an ETL process using Dataflows and were loaded into

the project's Data Warehouse. Thus, the data collection methods consistently prioritized reliability and updating capacity of the sources, supporting the robustness of the BI model and ensuring that the insights generated are grounded in empirical and trustful evidence.

3.3. THE COHORT-COMPONENT METHOD

3.3.1. OVERVIEW AND RELEVANCE FOR THE RESEARCH

As previously mentioned, one of the main objectives of this research is to conduct a foresight analysis, aiming to project future demographic dynamics and assess its impacts in the Setúbal Peninsula's demography up to 2041. To achieve this, the Cohort-Component Method was chosen as the core forecasting method, since it is particularly suitable for projecting population evolution based on different structural demographic variables (Bravo et al., 2018), making it ideal in the context of this research.

The Cohort-Component Method is widely recognized in the demography field due to its robustness and comprehensiveness, being used in official population projections (United Nations, Department of Economic and Social Affairs, Population Division [UN DESA], 2024; Rodrigues, 2024; Bravo et al., 2018; Rodrigues et al., 2009). The method is built upon three fundamental drivers of demographic change within a certain population, which are fertility, mortality and migration, all three able to influence how a population can increase or decrease throughout time. Thus, these three components, combined, work as important metrics to determine the evolution of a population over time. In simple terms, the method relies on the resident population concept, where an initial baseline population is segmented by gender and age into different groups, called cohorts. In the case of this research, and as mentioned before, the initial baseline population derives from the 2021 Portuguese Census data (INE, 2025). Once the cohorts are determined, they are iteratively updated, based on the application of the three key components and, thereby, enabling the construction of multiple scenarios. In this research, three different scenarios were considered: optimistic, moderate and pessimistic.

This method is the most suitable for long-term demographic projections (Bravo et al., 2018), as it enables the creation of multiple future demographic scenarios, allowing for an overview of different potential evolutions based on varying assumptions about fertility and mortality rates, alongside with migration flows. It is also important to highlight that the method has been internationally validated, and it is widely used in the field of demographic studies, being inclusively applied in all editions of the World Population Prospects, conducted by the United Nations Department of Economic and Social Affairs (UN DESA, 2024) since the half of the 20th century. Also, research such as Bravo's et al. (2018) and Rodrigues' et al. (2009) also endorses the use of the method for this particular purpose, validating its choice for this research. Since gentrification has a cause-consequence relation with the concept of population

displacement, this method provides a structured approach to properly forecast resident mobility and demographic transformations within the Setúbal Peninsula.

Within the Design Science Research Methodology (DSRM) framework, which is the main methodological approach in this research, the Cohort-Component Method is included both in the Design and Development phase, as it is in the Demonstration phase. It is related to the development since it represents the mathematical model that will be used to generate demographic projections up to 2041, using for this purpose the Census data as an input. The projections, on the other hand, will also serve as a foundation for further analysis itself, being also an input data for the implementation of the BI solution. Regarding the Demonstration phase, the projections will be mainstream to allow a proper comparison between the current demographic trends with the predicted future scenarios. Since the final output of this research is the BI solution, the artifact itself relies on the demographic forecasts produced by the application of the Cohort-Component Method, as they act as a core input for successfully achieving its goals, allowing for the generation of analytical value.

3.3.2. THE THREE COMPONENTS OF THE COHORT-COMPONENT METHOD

As referred, the correct application of the Cohort-Component Method relies on an initial baseline population, which establishes the resident population at the starting point of the projections. For this research, the main source is the 2021 Census data, as previously referred. Once the baseline population is determined, it must be segmented into age-gender specific cohorts, which will be dynamically updated as the model progresses through future time intervals. Each one of these cohorts consists of a group of individuals born within the same time period, as this specific segmentation allows the tracking of population dynamics over time, since a certain group of people might switch cohorts depending on the evolution of time. The cohorts move forward in time, transitioning to the next age bracket in successive projection periods, usually in five-year intervals. As the analysis progresses, the three demographic components are applied to these cohorts, in order to simulate real-world population changes.

The Mortality Component determines the decrease of a certain population over time, through the application of age-specific mortality rates to each one of the cohorts, aiming to determine the probability of survival for each one of them. For each five-year interval, individuals considered as non-survivals shall be removed from their respective cohort, while the remaining individuals transition to the next age bracket. According to Rodrigues (2024), of all three components, it may be considered the most stable, as mortality patterns are often more predictable. However, and especially given a population as the Portuguese one, with a notable increase of upper age brackets, some uncertainties might be found, regarding increase in life expectancy. Thus, to project mortality, it is recommended to use the latest available life table of the studied population, assuming the studied population will follow the same mortality

trend over time. It is the case of Princeton Model Life Tables, a set of standardized mortality tables, which is used in this research.

The Fertility Component, on the other hand, determines the increase of a certain population over time, through the application of age-specific fertility rates on women in reproductive age groups. For each five-year interval, newborns are allocated into male and female categories based on the observed sex ratios at birth. It is a more complex component than mortality, as birth rates are directly influenced by sociocultural and economic factors.

Lastly, the Migration Component takes into consideration in-migration and out-migration rates, estimated based on historical migration flows and socioeconomic factors which may influence mobility in a certain location. However, it is the most challenging component to forecast, which according to Rodrigues (2024), might be explained by: i) the lack of reliable data sources, since migration statistics are often based on indirect and inconsistent estimations; ii) its high sensitivity to economic and social fluctuations, unlike to mortality and fertility, which are more stable, since migration patterns can be significantly influenced by short-term economic and political cycles; iii) the lower methodological accuracy in measurement, since the existing models for estimating migration rates are less precise than those for birth and death rates, as migration flows are more volatile and harder to systematically track. Given these challenges, these type of projections do not aim to estimate proper numbers of immigrants or emigrants, but net migration balances, which reflect the overall difference between in-migration and out-migration for each one of the cohorts. Given the nature of migration patterns, the foresight is forced to consider multiple migration scenarios, adjusting variables to compare possible demographic futures.

Thus, the Cohort-Component Method provides a structured framework to demographic projections, by systematically applying mortality, fertility, and migration components to age and gender-specific cohorts.

3.3.3. IMPLEMENTATION OF THE COHORT-COMPONENT METHOD

Relying on the methodological approach proposed by Rodrigues (2024) and Bravo et al. (2018), the initial baseline population was retrieved from the source already disaggregated into cohorts by gender and age group, for each of the ten municipalities considered in this study, which are the nine municipalities of the Setúbal Peninsula, namely Alcochete, Almada, Barreiro, Moita, Montijo, Palmela, Seixal, Sesimbra, and Setúbal, plus the city of Lisbon. It is important to highlight that the method was uniformly applied across all municipalities, using the same assumptions and parameters, under three distinct demographic scenarios: pessimistic, moderate, and optimistic, each reflecting different hypothetical population evolution. Besides the total population data, municipality-level data was also retrieved on live births, total deaths, infant deaths, and net migration, serving as inputs for the calculation of

the three key demographic rates, related to the three main components: Infant Mortality Rate (IMR), General Fertility Rate (GFR) and Migration Growth Rate (MGR).

The mortality component of the projection was applied through the estimation of the number of survivors within each cohort for each quinquennium, and for that, the appropriate survival rates, derived from mortality levels, were applied to each cohort. To obtain the survival rates, the Infant Mortality Rate (IMR) was first calculated and then combined with life expectancy at birth (E0), as observed in the complete life tables for the Portuguese population. The IMR calculation was given by the following equation (0.1), obtaining the values presented in Table 0.1.

$$IMR = \frac{Deaths < 1 Year}{Total Births} \times 1.000 \quad (3.1)$$

Table 3.1 – IMR + E0 (Portugal)

Period	IMR	E0 (M)	E0 (F)
2000-2001	5,81	73,25	80,05
2010-2011	2,92	76,67	82,60
2020-2021	2,70	78,05	83,52

Based on the IMR and E0, the study adopted the Model 27W of the Princeton Model Life Table, which is considered more appropriate for populations with low infant mortality, as is the case of the Portuguese one. The table can be seen below.

Table 3.2 - Princeton Model Life Table

Model	IMR	E0 (M)	E0 (F)
20 S	67	64	68
21 S	52	66	70
22 S	38	68	73
23 S	24	70	75
24 S	15	72	78
24W	11	72	78
25W	7	74	80
26W	5	76	83
27W	4	79	85

Lastly, the 27W Princeton Model provided age and sex-specific survival coefficients, which were then used to calculate the proportion of survivors in each age cohort, during each quinquennium interval:

Table 3.3 - Model 27W Survival Coefficients

Age Group	27 W (M)	27 W (F)
0	0,99556	0,99645
1	0,99929	0,99945
5	0,99979	0,99987
10	0,99909	0,99966
15	0,99735	0,99916
20	0,99589	0,99869
25	0,99574	0,99841
30	0,99571	0,99805
35	0,99412	0,99717
40	0,99081	0,9956
45	0,98387	0,99266
50	0,9756	0,98937
55	0,96503	0,98523
60	0,94678	0,97809
65	0,91582	0,96353
70	0,73373	0,72478
75	0,73373	0,72478
80	0,73373	0,72478
85+	0,73373	0,72478

These coefficients were directly applied to the 2021 baseline population, cohort by cohort, by multiplying the total population of each cohort by the corresponding survival coefficient, thus producing the projected population for the subsequent period, and this process was repeated, iteratively, for each quinquennium until 2041, using for that the Lexis Diagram.

The fertility component, on the other hand, was projected based on the General Fertility Rate (GFR), calculated using the following equation (0.2), expressing the number of live births per 1.000 women of reproductive age (15–49 years).

$$\text{GFR} = \frac{\text{Total Births}}{\text{Women 15-49 Years}} \times 1.000 \quad (3.2)$$

Through the calculation of the GFR for each five-year period, it was possible to determine the average GFR for each quinquennium, enabling the estimation of the likely number of births during each projected time interval. The projected births obtained by the application of the GFR in the predicted female populations were then distributed by sex, according to the gender proportion observed in the total population for each respective year and then added to the Lexis Diagram as input for predicting the survivals for the 0-4 years cohort. Differently from the mortality component, in which the same survival coefficients were applied uniformly across all three projected scenarios, fertility was measured in a different way across the three hypothetical scenarios, always based on the initial GFR, from the 2021 baseline female population.

In the pessimistic scenario, the measurement of the GFR took into consideration the historical GFR from each past quinquennium, from 2001 to 2021. Based on these values, an average annual percentage variation was calculated and, aligning with the national Portuguese trends, resulted in a negative rate across all observed municipalities. Then, this negative variation rate was then subtracted incrementally from the initial GFR, every five years, generating a scenario of continuous fertility decline.

For calculating the GFR in the optimistic scenario, the recent annual GFR values from 2021 to 2024 were then considered. Given the observed population growth in the region over the past quinquennium, the average annual percentage variation, in this case, resulted in a positive trend in all municipalities. Accordingly, this positive variation was added incrementally to the initial GFR every five years, creating a scenario of fertility growth.

Finally, in the moderate scenario, the same recent annual GFR values from 2021 to 2024 were considered to calculate the average annual percentage variation. However, in this specific scenario the intention was to avoid overestimating growth and to produce a balanced projection between the pessimistic and optimistic ones. Because of that, this positive variation was progressively cut in half every five years, allowing the production of an intermediate scenario, that moderates the assumptions of the optimistic case and is not too pessimistic as the first one.

However, and besides projecting three alternative scenarios, it is important to note that, even in the optimistic scenario, where the GFR increases gradually over the projection period, the total number of live births still shows a decline across every quinquennium, which underscores the ongoing downward trend in Portuguese fertility, reinforcing projections of reduced natality in the coming decades.

In order to illustrate the explained procedure, the table below shows the GFR values obtained for each one of the three scenarios, across each five-year interval, for the city of Lisbon. However, the procedure was applied to each one of the ten municipalities studied in this research. For the pessimistic scenario, the average annual percentage variation assumes the value of -1,178%, while in the optimistic scenario, the value is represented by 0,43%, being progressively halved in the moderate scenario.

Table 3.4 - GFR Projections in Lisbon (2021-2041)

Period	GFR (PES)	GFR (MOD)	GFR (OPT)
2021	44,3	44,3	44,3
2021-2026	43,7	44,5	44,5
2026	43,1	44,7	44,7
2026-2031	42,5	44,8	45,0
2031	42,0	45,0	45,2
2031-2036	41,4	45,0	45,4
2036	40,8	45,1	45,6
2036-2041	40,2	45,1	45,8
2041	39,6	45,1	46,0

By applying the mortality and the fertility components to the studied population, it was possible to obtain the natural growth rate of the region. However, it is important to add to this projections the migration component, the third and more complex one (Rodrigues, 2024) from the three main components of the Cohort-Component Method, if the intention is to obtain the most accurate predictions possible for the future scenarios.

Based on this premise, the migration component was subsequently calculated for the three different hypothetical scenarios, and then added to the natural population projections, allowing the estimation of the final population for each quinquennium. For each one of the three possible scenarios, a distinct Migration Growth Rate (MGR) was calculated, however, it is important to highlight that, given the current migratory context in Portugal and the percentage values obtained from the application of the MGR functions, all three scenarios present a positive MGR, consistently reflecting a migration-attractive environment, rather than a repulsive one.

In order to calculate the pessimistic MGR, both the Average Annual Growth Rate (AAGR) and the Natural Growth Rate (NGR) were taken into consideration. The AAGR represents the average yearly growth rate of the population over the last two five-year periods (2011 to 2021), and was calculated using the following equation:

$$AAGR = \left[10 \left(0.1 \times \log\left(\frac{FinalPop}{InitialPop}\right) \right) \right] - 1 \quad (3.3)$$

The NGR, on the other hand, represents the average annual population growth excluding migration, considering only births (B) and deaths (D) over the same period, in this case, 2011 to 2021, and was calculated using the following equation, which allows to obtain the theoretical population, in case migrations did not occur:

$$NGR = \left[10 \left(0.1 \times \log\left(\frac{InitialPop+B-D}{InitialPop}\right) \right) \right] - 1 \quad (3.4)$$

Thus, the pessimistic MGR was then obtained by calculating the difference between AAGR and NGR, representing the historical migratory contribution to population growth over the last decade:

$$MGR (PES) = AAGR - NGR \quad (3.5)$$

For calculating the MGR in the optimistic scenario, on the other hand, the recent annual MGR values from 2021 to 2024 were then considered, given the historical data also obtained from INE, which allows the observation of an immigrant population growth scenario in the region over the past quinquennium. Similar to the GFR calculation, the average annual percentage variation was calculated considering the MGR values, which resulted in a positive trend in all municipalities as well, being directly used as the optimistic annual MGR value.

Finally, in the moderate scenario, and since this specific scenario intends to avoid overestimations, a simple average was calculated between the pessimistic and optimistic MGRs, which allowed the production of a balanced, more realistic, moderate MGR.

Once the annual MGRs were calculated, they were all extrapolated to a five-year period in each scenario, resulting in a quinquennial MGR, which was then applied iteratively. Firstly, they were applied to the baseline population of 2021, and then successively to the naturally projected populations, from 2026 to 2041. In each projection round, the number of estimated migrants per quinquennium was again distributed across the population, according to the existing age and gender cohort structure, ensuring consistency with the demographic breakdown. The number of immigrants were then added to the natural projections within a new Lexis Diagram, allowing, through this, the full integration of migration into the final demographic scenarios.

Thus, the implementation of the Cohort-Component Method to the baseline population resulted in three distinct outputs for the analysis of demographic trends in the Setúbal Peninsula: a pessimistic output, a moderate output, and an optimistic output, each reflecting the projections derived from their respective scenarios.

4. DESIGN AND DEVELOPMENT

4.1. END-TO-END BI SOLUTION ARCHITECTURE

As previously outlined in the methodological chapter, during the Design and Development phase of the research, an end-to-end Business Intelligence (BI) model was designed and implemented within the Microsoft Fabric environment, in order to achieve the research goals and better display the findings, as an output of the implementation of the Cohort-Component Method. This solution was designed to support a structured, end-to-end data pipeline, capable of providing insights on the demographic trends and dynamics in the Setúbal Peninsula, particularly as a result of Lisbon's gentrification spillover effects.

Thus, the core artifact developed in this covers the entire data workflow, from the raw data to the relevant insights shown through an interactive dashboard. The entire architecture was designed to ensure scalability, analytical depth, and easy maintenance, following a layered approach which integrated different Microsoft Fabric components for data ingestion, transformation, storage, and visualization, guided by design principles and best practices in data engineering and BI modeling (Kimball & Ross, 2013).

The first step in the development of this solution involves data collection and proper storage, ensuring the integration of different data sources into a consolidated file. For this purpose, structured datasets were retrieved from INE, providing demographic data from the 2021 Census and other historical statistics, essential for the application of the Cohort-Component Method, the first analytical intervention. Using the three components previously described in the past chapter, three different populational growth scenarios were projected: a pessimistic one, a moderate one, and an optimistic one. These projections considered the population baseline from the 2021 Census and were iteratively applied in five-year intervals (quinquenniums) until 2041, leading to separate outputs for each scenario. Thus, the three outputs were then stored in a pattern file, in a structured way, using Microsoft SharePoint as the data storage layer of the solution, storing the output files with the projections, alongside with the dimensional support tables, for later processing in the Dataflows.

Already inside the Microsoft Fabric environment, all data transformation was performed through Microsoft Fabric's Dataflows Gen2, using Power Query as a transformation layer to apply cleansing rules and standardize table formats in M queries workflows. Once prepared, the data was then loaded into a Data Warehouse, which may be considered the core repository within the context of this research, once it stores the already transformed and prepared data into a proper dimensional model, following the standards proposed by Kimball and Ross (2013). Within the Data Warehouse, the data was structured into fact tables containing measurable facts such as total population, but also into dimension tables containing categorical attributes such as time periods, location and demographic attributes, simplifying data integration and the establishment of relationships between different dimensions and facts, in a further step. Since the Data Warehouse acts in this context as a

repository for all the data, a Semantic Model was also developed in order to bridge the gap between the Warehouse and the reporting layer, allowing for the establishment of the dimensional model and development of measures with DAX (Data Analysis Expressions) in an intermediate layer.

Lastly, the final step of the end-to-end solution involved the development of an interactive dashboard, using Power BI Desktop and further publishing it into the Microsoft Fabric workspace. The dashboard serves as the main interface for intuitive exploration and analysis of the processed data, enabling the identification of the demographic trends and correlations across different municipalities and future scenarios. Thus, it will be further described and evaluated, considering the established criteria pointed out in the methodological chapter.

This architecture, built completely from the raw data to the proper insights, can be seen as the core artifact of this research, since it ensures a unified ecosystem to support decision-making in the demographic field, concerning the demographic shifts occurring in the Setúbal Peninsula for the next fifteen years. The workflow below visually presents the model architecture, which will be evaluated in the discussion chapter.

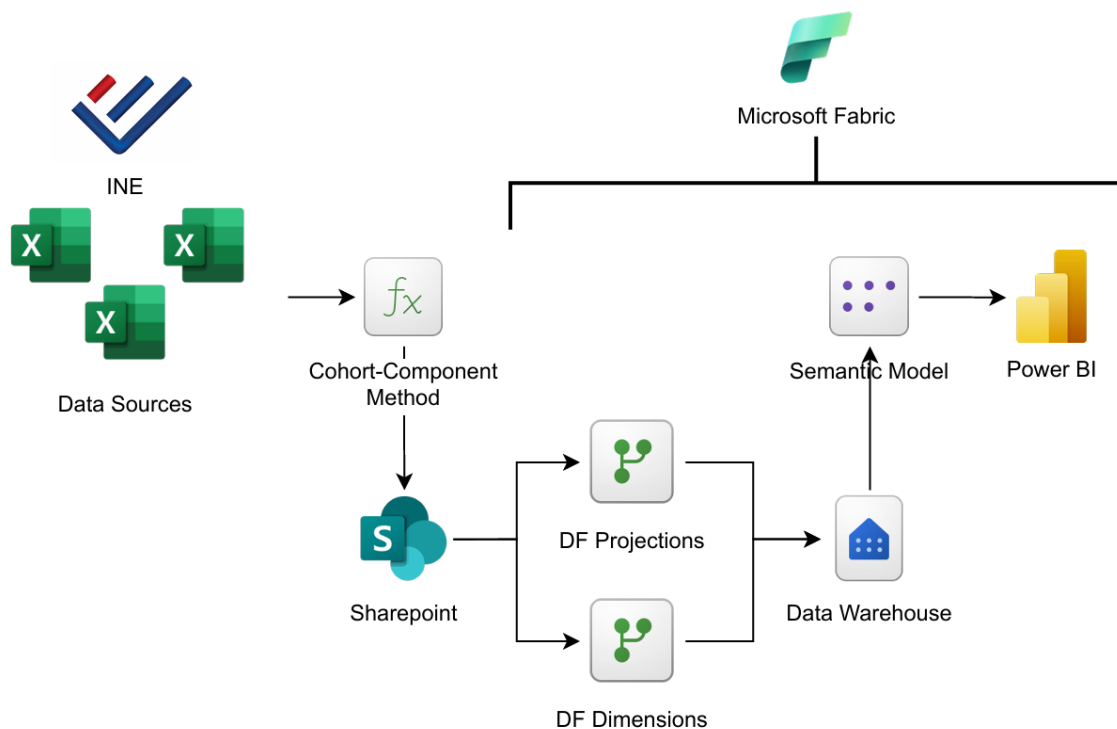


Figure 4.1 - End-To-End BI Solution Architecture (Own Elaboration)

4.2. DIMENSIONAL MODEL ARCHITECTURE

As mentioned, the data was stored in a Data Warehouse, relying on a Semantic Model to establish a dimensional model and the development of measures. Following Kimball & Ross

(2013) principles, the dimensional model adopted a Star Schema architecture, with a centered fact table containing the projected population across time, alongside with all dimensions (Soares et al., 2022) represented by foreign keys (FK), allowing the connection with the dimension tables through their respective primary key (PK), which enriches the dataset with descriptive attributes. The following image represents the Star Schema, inside the Semantic Model.

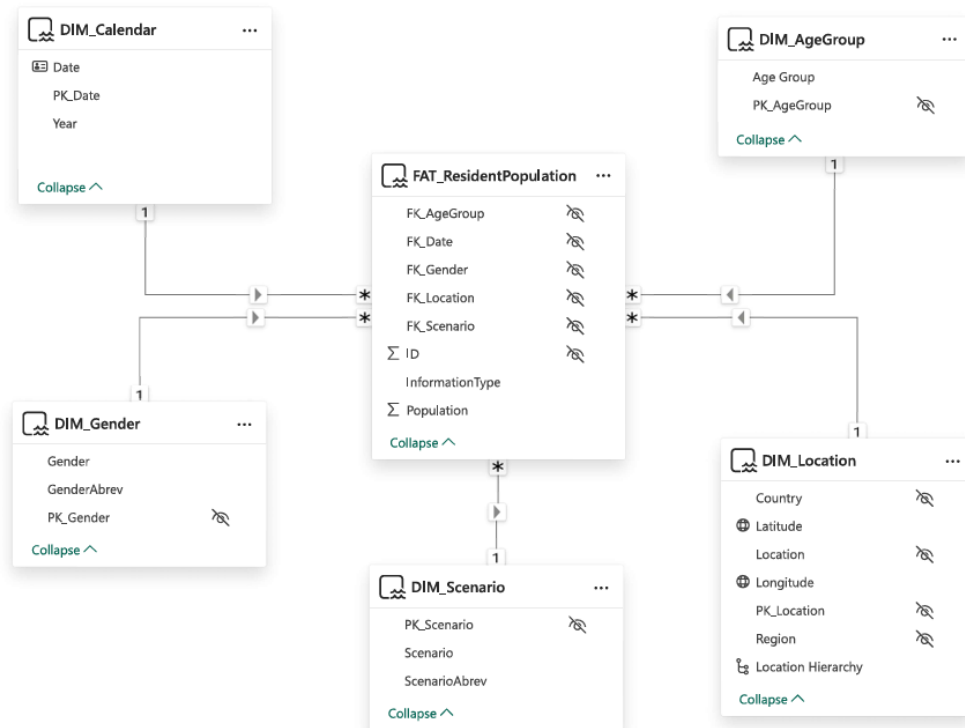


Figure 4.2 - Dimensional Model Star Schema (Own Elaboration)

Thus, the dimensional model comprises one fact table (**FAT_ResidentPopulation**) with the population predictions for all three scenarios, and five dimensional tables, containing demographic data that provide context to the fact table:

- **DIM_Calendar**: provides time granularity, with all quinquennium (2001-2041).
- **DIM_Location**: provides location granularity, with all the municipalities studied.
- **DIM_AgeGroup**: provides the disaggregation of population by age groups.
- **DIM_Gender**: provides the disaggregation of population by gender.
- **DIM_Scenario**: provides the distinction between the three projected population pathways (optimistic, moderate, and pessimistic).

4.3. KEY PERFORMANCE INDICATORS (KPIs)

4.3.1. RELEVANCE FOR THE RESEARCH

As quantifiable metrics often used to evaluate the effectiveness of a given project, initiative or business strategy, Key Performance Indicators (KPIs) are critical tools for translating complex metrics into meaningful information (Badawy, et al., 2016). These indicators are designed to be measurable, relevant, and to enable decision-making based on empirical data and information. In the scope of this research, one of the main objectives falls upon the definition and development of KPIs based on demographic data to quantitatively measure the spillover effects of Lisbon's gentrification on the region's demography, directly affecting urban livability and calling attention to the necessity of data-driven urban planning.

Therefore, KPIs play a fundamental role in addressing this objective, since they help measuring direct and indirect impacts of demographic shifts through objective and intelligible indicators. The usage of KPIs in urban analytics is quite important for supporting the understanding of demographic trends, and in this case, they provide a structured framework for continuous monitoring of demographic dynamics, making it possible to identify trends and compare them with the forecasted future scenarios.

4.3.2. MEASURING URBAN LIVABILITY AND DEMOGRAPHIC INDICATORS

As previously mentioned, it is a consensus in literature that, although urban livability is mostly perceived by qualitative analysis on citizen's perceptions, it can also be effectively measured through objective and quantitative indicators. This idea is supported by different researchers (Khorrami et al., 2020; Kim et al., 2021; Louro et al., 2021; Chen, 2022; Schindler & Dionisio, 2024), under the light of the fact that, despite the inherently multifaced and subjective nature of urban livability, it is important to establish a consolidated set of metrics to assess it in a reliable and structured manner. Given the research objectives, this quantitative perspective is particularly relevant for analyzing the spillover effects of Lisbon's gentrification into the Setúbal Peninsula because it allows the creation of insightful measures to assess the demographic trends in the region.

Regarding the measurement of urban livability indicators, the work of Khorrami et al. (2020) must be highlighted. The researchers performed a scoping review of sixty-seven academic articles, in order to identify the most relevant indicators and methodologies used for measuring urban livability, enabling the establishment of the most important indexes and methodologies for assessing urban livability in a quantitative perspective. The indicators included in their findings are related to multiple domains, however, for the purpose of this research, indicators associated with population dynamics are particularly interesting to take into consideration.

Furthermore, Khorrami et al.'s (2020) scoping review revealed a trend towards the usage of data-driven and quantitative assessments of the subject, aligning with the methodological approach of this research. From the sixty-seven studies reviewed, only 23% used qualitative methods, while the rest 77% adopted quantitative approaches to evaluate urban livability, allowing for the comparison between different cities from different cultural environments across the globe. Due to the complexity of the livability concept, it becomes a hard subject to assess (Khorrami et al., 2020), highlighting the importance of properly selecting the more appropriate indicators for the specific topic of the research.

Considering Khorrami et al.'s (2020) full list of indicators found in each study reviewed, it is important to take into consideration relevant demographic indicators (INE, 2025; Bravo et al., 2018; Rodrigues et al., 2009), aiming to develop a more comprehensive assessment of the spillover effects of Lisbon's gentrification on the Setúbal Peninsula demographic trends, particularly in terms of population growth and the resulting impacts on quality of life. This characterization of the population of the region is fundamental, because the study not only intends to understand the shifts in the dynamics of the demography, but mostly to capture the broader social transformations taking place in the Peninsula social fabric.

Indeed, and considering the demographic changes from the last years, the suburbanization of the Portuguese capital, resulting from gentrification, lead to significant modifications in the social fabric of its surrounding municipalities. While the influence of gentrification on housing markets is a natural flow of the phenomenon, gentrification's impacts are also shown through changes into the sociodemographic composition of local communities, thus, outlining the importance of selecting indicators capable of detecting new trends and patterns of population replacement that may be redefining the characteristics of the Setúbal Peninsula's resident population.

Considering the data sources, it becomes possible to identify and calculate such indicators and metrics, which provide critical insights into the ongoing transformation processes, and allow the development of the project's main KPIs. Through these metrics, the research can achieve its main objectives, connecting demographic and socioeconomic dimensions of gentrification. For organizational purposes, the following indicators were listed containing the indicator and its definition:

- **Total Resident Population:** total number of residents in each municipality.
- **% Population Growth:** percentage change in total population over a given period.
- **Youth Index:** ratio of the population aged 0–14 to the population aged 65 and over.
- **Ageing Index:** ratio of the population aged 65 and over to the population aged 0–14.
- **Dependency Index:** ratio of the dependent population (ages 0–14 and 65+) to the working-age population (15–64).

- **Longevity Index:** ratio of the population aged 85 and over to the population aged 65 and over.
- **Potential Index:** ratio of the population aged 0–14 to the population aged 15–64.
- **Trend Index:** ratio of the population aged 15–24 to the population aged 65 and over.
- **Active Youth Index:** ratio of the population aged 15–24 to the population aged 0–14.
- **Active Population Renewal Index:** ratio of the population aged 20–29 to the population aged 55–64.

Thus, Khorrami et al.'s (2020) list of main indicators, alongside with the demographic indicators obtained from INE's data sources, provides a baseline framework for developing this study's KPIs, considering both the indicators found in previous studies and the availability of data retrieved from the data sources previously mentioned. All indicators were calculated recurring to DAX measures in Power BI, being displayed in the final dashboard.

4.4. DASHBOARD IMPLEMENTATION

The final step of the end-to-end BI solution involved the development of an interactive dashboard, using Power BI to create the main interface for intuitive exploration and analysis of the projected data, enabling the identification of the demographic trends and correlations across different municipalities and future scenarios. The image below shows the final artifact mock-up, which was followed as a guideline for the dashboard construction.

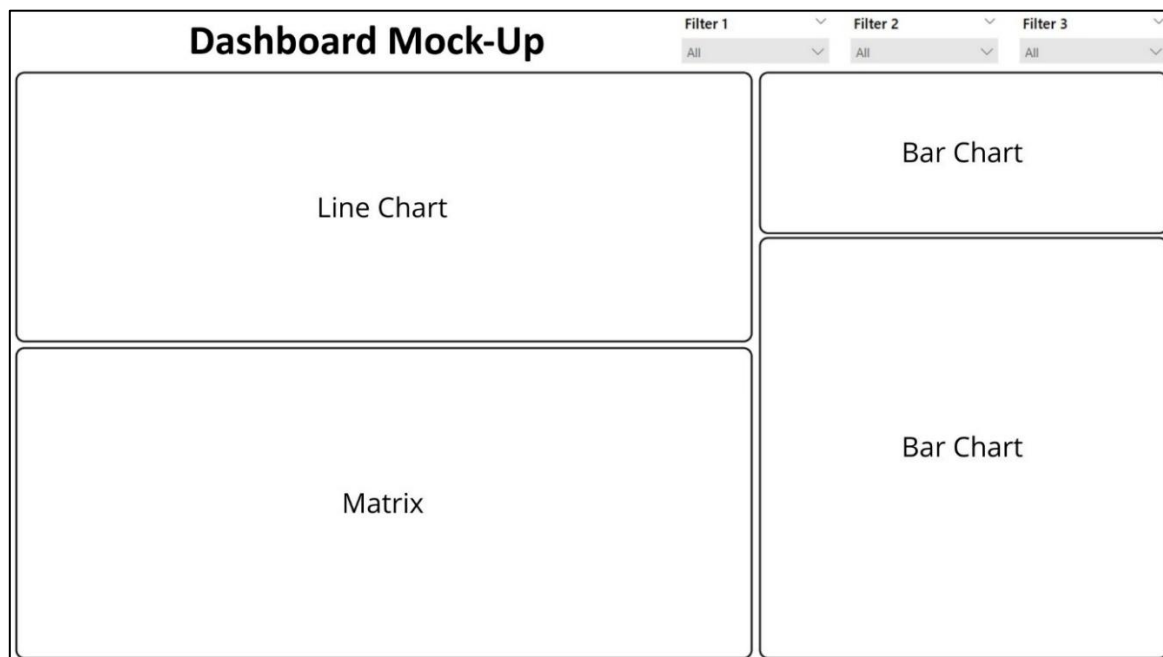


Figure 4.3 - Dashboard Mock-Up (Own Elaboration)

Based on the dimensional model previously outlined, this dashboard was developed to, and based on the retrieved data alongside the prospectives, provides an answer to the research question and to the objectives defined during the definition of objectives for a solution stage of the DSRM.

With a design that prioritizes visual clarity and simplicity, focusing on what matters most, which are the demographic projections and the evolution of population dynamics over time, particularly in terms of growth potential, ageing, renewal, gender distribution, and age group segmentation, and aiming to ensure an user-friendly experience and full interactivity, the dashboard was implemented as a single-paged artifact, featuring four core visual elements. Despite its minimalist structure, these visuals were carefully chosen for their analytical precision and their ability to directly support the research objectives, which will be further explored in the subsequent chapter.

Describing the dashboard, as initially proposed in the mock-up, the tool incorporates three interactive slicers that enhance user interactivity and allow for refined analysis. The first slicer enables filtering by year, which supports both comparative and timely analyses of demographic trends. The second slicer, on the other hand, enables filtering by location, offering a hierarchical structure from region (Greater Lisbon or Setúbal Peninsula) down to the municipality level, which showcases the municipality-focused granularity of the data, allowing for different approaches on the exploration of the data. Lastly, the third slicer allows users to select between the three projection scenarios (optimistic, moderate, and pessimistic), however, it is important to highlight that, by default, the dashboard displays data according to the moderate scenario, as it represents the intermediate and most stable one among all three projections. Thus, final users are able to switch scenarios through the slicer to generate new insights and make comparative assessments between hypotheses.

In terms of visualizations, the dashboard includes a line chart, which displays the total regional population from 2001 to 2041, with the baseline data being represented by a solid line, while the projected data is shown with three dashed lines, one for each of the scenarios. This visual is particularly important for providing a clear, quick and intuitive overview of population evolution, and distinguishes well between historical trends and forward-looking projections.

Secondly, the dashboard presents a matrix table, which serves as the main visual for the demographic indicator analysis. The matrix was designed to display the calculated indicators by municipality hierarchy and year, enabling side-by-side comparisons between different municipalities and across time, directly supporting one of the key aims of the research: to identify trends and differences in demographic behavior across the studied regions.

Positioned in the upper-right corner, the dashboard presents a bar chart showcasing the annual population growth rate and, unlike the line chart, which shows absolute values regarding the total population, this visual offers a relative perspective on population changes

over time, being particularly effective for identifying short-term shifts and understanding year-over-year dynamics.

Lastly, and of extreme importance in demographic analysis, the final visual represents a demographic pyramid, displaying population distribution by gender and age group, it is, by cohorts. The demographic pyramid becomes especially valuable when slicers are applied, allowing users to observe the effects of demographic transitions in population distribution over time. Without requiring the analysis of the percentage indicators shown in the matrix visual, the pyramid visually reveals key patterns such as ageing, youth representation, and workforce renewal, offering an intuitive and visual understanding of structural demographic dynamics.

The image below illustrates the final dashboard, developed based on the initial mock-up. Its utility, alignment with the research objectives, and effectiveness in addressing the research problem will be critically evaluated in the following chapter, through an assessment of results and discussion.

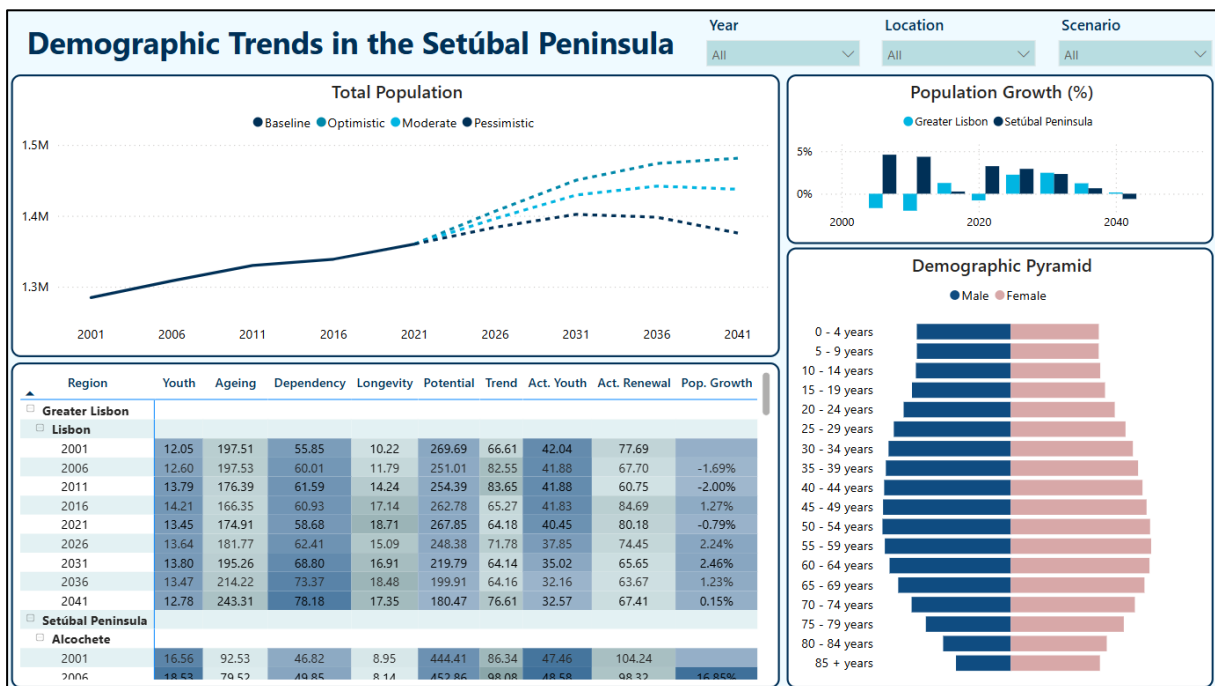


Figure 4.4³ - Dashboard: Demographic Trends in the Setúbal Peninsula (Own Elaboration)

³https://app.powerbi.com/links/5uQ8BmqOzD?ctid=e4bd69ff-e6f7-4c2e-b247-41b54ba2490e&pbj_source=linkShare

5. RESULTS AND DISCUSSION

5.1. ARTIFACT EVALUATION

Considering the Design Science Research Methodology (DSRM), adopted in this research, the Evaluation phase represents a central role in properly assessing whether the developed artifact effectively addresses the pre-defined research problem (Peppers et al. 2007), and if it properly provides support for the research objectives. As defined in the methodological chapter, the end-to-end BI solution produced through this research is evaluated based on its usability and meaningfulness, and has been iteratively tested and redesigned, to determine how well the model is capturing and highlighting the demographic trends in the region.

Taking into account the assessment criterion defined in the methodological chapter, and considering that the primary goal of the artifact is to properly support the research objectives, providing reliable data for a demographic analysis, the model was assessed by relating to the specific research objectives, consisting in three questions to be answered:

The first question, related to the first research objective, is the following: does the model accurately capture current demographic trends and provide clear visualization of the predicted scenarios, allowing for comparison and evolution analysis?

After testing the final dashboard, we can acknowledge that the model successfully captures and reflects both the historical and prospective demographic trends across the specific regions studied, namely the city of Lisbon and all municipalities of the Setúbal Peninsula. Mostly because of the design choices, through a combination of descriptive and projective visualizations such is the case of the line chart displaying population evolution and the demographic pyramid illustrating population structure by cohorts, the model allows for a clear, straightforward and, most of all, interactive understanding of the demographic behavior in this specific municipalities over time, and as so, the users are able to observe not only population growth or decline, but also key structural transformations, which are indispensable to answering the research question. Additionally, the distinction between historical baseline data and the projected scenarios, made possible through the establishment of different line styles between these two components, makes it quick, precise and direct to identify the turning points and differences between all the three possible futures, supporting an effective temporal and comparative analysis, aligning with the objective of understanding the demographic evolution.

Related to the second research objective, the second question asks: are the selected KPIs effective in quantitatively measuring structural changes driven by spillover pressures?

Regarding this question, it is possible to acknowledge that all the KPIs implemented are quite well-aligned with the established prediction methodology and the existing literature (INE, 2025; Khorrami et al., 2020; Bravo et al., 2018; Rodrigues et al., 2009), since they

quantitatively measure structural dimensions of the studied populations and, when tracked and compared over time and across municipalities, enable the identification of important patterns, consistent with the possible spillover effects, which will be analyzed deeper in the following chapter. The ability to analyze these indicators at both regional and municipal levels, across different time points and scenarios, allow the users to detect detailed changes in population structure that may reflect broader socio-spatial dynamics, including the ones in the scope of this research, which are gentrification and displacement. Moreover, the matrix visual makes it easier for comparisons, enabling offering a comprehensive overview for each municipality, but also a deeper view of how demographic indicators behave across space and time, thus reinforcing the interpretability and robustness of the KPIs in supporting this research objective.

Lastly, the third question, related to the third research objective, which is to conduct the foresight analysis, is the following: does the predictive component effectively project future demographic trends and different scenarios?

This might probably be the easiest question to answer, and after testing and interacting with the dashboard, the answer is positive. The predictive component of the research, properly embedded in the scenario-oriented projections, effectively enables foresight analysis, with a high degree of clarity and methodological rigor in reproducing the most accurate predictions as possible, which goes through the selection of the Cohort-Component Method, but also through the definition of the three components main rates that allows the proper predictions. By incorporating three scenarios, the users obtain hypothesis to observe, which is a core in the demographic field. We must not forget that being a social science, there is also a degree of uncertainty in demographic predictions, and that is why the presentation of three scenarios is so important, because it tends to stabilize this uncertainty by presenting more than just one single hypothesis. Thus, the designed model offers a flexible and detailed analytical tool, fulfilling this objective. The capability of visualizing the projections through both charts and tables captures the implications of different assumptions regarding the three components, supporting strategic decision-making, thus aligning with the literature and objectives.

In the overall consideration, it is acknowledged that the artifact meets the evaluation criteria with a high level of effectiveness, providing coherent and straightforward answers to the research objectives, since it allows an interactive and analytical tool for representing the demographic trends and projections in the region. In terms of usability, the dashboard is strengthened by a clean interface and flexible slicers, and its analytical capacity is mostly grounded in the selection of meaningful KPIs regarding the research topic and the three scenario-oriented projections perspective. Furthermore, the artifact aligns with the iterative nature of a DSRM framework, standing opened for future improvements and integration with different types of data and indicators, being possible to apply continuous refinement in further research. Thus, the Evaluation confirms that the end-to-end BI solution proposed successfully addresses its goals, delivering valuable insights for demographic trends analysis.

5.2. DEMOGRAPHIC TRENDS IN THE SETÚBAL PENINSULA

After evaluating the artifact effectiveness, this chapter intends to perform a data storytelling on the information presented in the developed dashboard, and as so, provide an analytical perspective to explain to what extent are the demographic trends in the Setúbal Peninsula possibly being affected by Lisbon's gentrification, and how can this spillover effect be measured through the demographic indicators constructed through this research.

The following analysis of results is directly based on the information displayed in the demographic trends dashboard, and intends to provide the main findings and expected demographic trends and behaviors in the projected years. Thus, the analysis will focus on the period between 2021 and 2041, focusing on the forecast. Firstly, at a regional level, it is highlighted in all three scenarios that the total population is expected to grow in the next decade. In the pessimistic scenario, however, the regional population is expected to start declining after 2036, while it is expected to stabilize in the moderate scenario, and keep growing in the optimistic one, which reveals main differences among scenarios.

At a municipality-level analysis, we shall begin with the core city among all the studied, which is the Portuguese capital. The evolution of Lisbon's indicators across all three scenarios reveals a clear trend of populational aging and declining of urban vitality, which is closely linked to the gentrification process explained in the literature review (Mendes, 2023). The youth index presents an initial growth in the first ten years, followed by a slight decrease after 2031, stabilizing between 11.8 (pessimistic) and 12.9 (optimistic), depending on the scenario. It indicates a weak generational replacement, reinforcing the decline of vitality. The aging index, on the other hand, rises significantly during the period, going from 174.9 in 2021 to over 240 in all three scenarios, reaching even the value of 265.3 in the pessimistic one. This shift is the clear reflection not only of the natural ageing trend that is constant in the whole country, but also one of the outcomes of gentrification, as highlighted by Glass (1964) and Mendes (2023), emphasizing the exclusion of young families and lower-income groups from urban centers due to gentrification issues, in what Hall (1998) calls a filtering up process.

Related to this trend, and following the same path, the pressure on the active population becomes increasingly evident when analyzing the dependency index, alongside with the active population renewal index. While the first one increases from 58.6 in 2021 to around 78.1 in 2041, the second one progressively decreases from 80.1 in 2021 to around 67.5 in 2041. Driven by displacement factors (Savage & Warde, 1993) such as the rising cost of urban life, a loss of productive population can be observed in the city, favoring the displacement of economically productive residents. Although Lisbon may show some capacity for active population renewal until 2041, the behavior of the youth index and the sharp decrease of potential index from 267.8 in 2021 to around 219.7 in 2031 to finally 180.4 in 2041 underscore the city's inability to renew its population organically, depending on external migration flows for this purpose, configuring as a rootless renewal (Estevens et al., 2023).

Given the evident ageing trend, the longevity index is consistent throughout the period, which shows two distinct sides of this scenario. Firstly, it is aligned with the ageing index, and thus reflects advances in overall population health and life expectancy. However, and as highlighted by Cocola-Gant and Gago (2021) and Savage and Ward (1993), the gentrification produces a selective aging process, marked by inequality, since the elderly who remains in the urban centers tend to be homeowners, with stable support, while the elderly with more vulnerability in terms of economic power tend to be displaced to other neighborhoods or even municipalities. For future research, this analysis would benefit from the integration of socioeconomic data alongside with the mentioned indexes, which would allow a better understanding of the economic conditions of the remaining population.

Finally, the population growth rate between 2021 and 2041 fluctuates sharply among the scenarios. In the pessimistic scenario, the total population of the Portuguese capital is expected to grow continuously until 2031, showing a 1.19% rate from 2021 to 2026, and then another positive rate of 1.34% from 2026 to 2031, with the expectation of stabilization from 2031 to 2036, following a decreasing path until 2041, with a negative rate of -1.12% from 2036 to 2041. In the moderate scenario, on the other hand, the stabilization of Lisbon's population comes later than in the pessimistic scenario, with the population achieving its peak in 2036, for then stabilizing in the next five years. Lastly, in the optimistic scenario, this stabilization is not verified, with the total population peaking in 2041. However, the population growth rate highlights an important decreasing trend, once it starts to gradually decrease from 2026 forward. By analyzing this trends and indicators, the most reliable and probable scenario to consider is the moderate one, given its alignment with both the demographic trends and the theoretical framework of this research, which reinforces the continuity of populational growth for the next ten years, but assumes the possibility of stabilization followed by decrease in 2041, highlighting the long-term effects of gentrification and resident population displacement.

Beyond Lisbon, and in a regional-level analysis, the Setúbal Peninsula is the core region studied in this research, and it is a crucial geographic space to the understanding of the suburban impacts of Lisbon's gentrification. All its nine municipalities, which are Alcochete, Almada, Barreiro, Moita, Montijo, Palmela, Seixal, Sesimbra and Setúbal shows consistent demographic shifts across all three scenarios, and some of these shifts might be understood as a consequence of the spillover effects caused by the rising urban pressure in Lisbon, as a driver for suburbanization (Figueiredo, 2022; Louro et al., 2021; Harris, 2015). Because of that, the demographic evolution observed across the Setúbal Peninsula cannot be fully understood without considering the suburbanization theoretical framework earlier presented.

Different from the capital, where populational growth tends to even reverse in the most pessimistic scenario, most of the suburban municipalities experience an overall consistent growth at least for the next decade, particularly under the moderate and optimistic scenarios,

reflecting an internal growth, but also considering the absorption of displaced residents (Harris, 2015) and the attractiveness for in-migration.

When analyzing the indexes for the Setúbal Peninsula, it becomes clear that the region follows a similar populational distribution structure as Lisbon, with some special cases. While all municipalities eventually follow the national aging trend, Almada, Moita, Montijo and Seixal stands out by presenting a relatively higher youth index and better active population renewal rates, at least until 2031, when the rates also start to slowly decrease in these municipalities. However, this behavior suggests that these four municipalities are potentially attracting younger families, reinforcing their roles as receiving poles in the suburban network.

Despite these exceptional cases, the aging index is expected to increase in all municipalities, a behavior that is also shared by the dependency index. This allows us to conclude that even the suburban areas are being affected by a natural aging trend, that affects the whole Portuguese population. However, the behavior of the demographic pyramid in these municipalities, when considered yearly, points out to a late demographic aging in the suburbs, which is aligned with the concept of suburbanization. Since these municipalities absorb more active population, distributed in middle age groups, the natural course is that these populations shall age in place over the next decades, as a replication of the same demographic pressures observed in Lisbon today.

Regarding the active population renewal Index, it is also noteworthy to highlight certain specific cases, because on one hand, the index generally exhibits a declining trend across most municipalities from 2021 to 2036, indicating a reduction in the proportion of the population considered to be actively renewing. However, apart from Montijo, Seixal, and Sesimbra, the index demonstrates a recovery by 2041 in all other municipalities, suggesting a potential demographic revitalization or influx of younger active individuals in these areas, after this period of decline.

When it comes to population growth, the most important indicator in the context of the Setúbal Peninsula, divergent patterns are shown across the nine municipalities. However, in regional terms, consistent growth is observed until 2036 in the moderate and optimistic scenarios, and until 2031 in the pessimistic one. This growth supports the idea of the region acting as a receiver of displaced population for at least the next decade, overcoming the negative natural balance. Considering the pessimistic scenario, the Peninsula's population is expected to exponentially grow until 2031, and then start declining for this quinquennium forward. In the other two scenarios, population achieves its peak in 2036 in the moderate scenario, and in 2041 in the optimistic one.

Based on the data displayed for all three scenarios, again, the most probable and coherent with the literature is the moderate one, showing the tendency of stabilization in the growth after the next decade. It is not controversial with what is presented in the case of Lisbon, and reinforces Smith's (1996) concept of *frontier of gentrification*. In a recall of the literature

review, the classic gentrification concept has progressively changed through time in terms of coverage, becoming applicable not only to the metropolis centers, but also to the metropolitan areas on their surroundings (Silva, 2022; Figueiredo, 2022). Smith's (1996) *frontier of gentrification* concept highlights this change in scope, explaining how urban development processes push outward from core areas into the peripheries, creating new cycles of displacement and urban transformation.

Thus, and despite the scenario-based variations, the overall population growth trajectory in the Setúbal Peninsula shows signs of deceleration after 2036, precisely suggesting a saturation of absorptive capacity and growing infrastructural pressures. This highlights clear symptoms of a cascading gentrification effect (Cortez, 2023), and also the consolidation of what was before anticipated by the Setúbal Peninsula Strategic Development Plan for 2020 (2014) regarding the capability of these municipalities infrastructures to handle with the demographic increase. The moderate scenario forecast reflects the classic gentrification displacement arc, where the suburban areas initially start benefiting from demographic inflow, but eventually inherit the same aging and dependency issues once dominant in the urban center (Glass, 1964; Estevens et al., 2023), in this case, the city of Lisbon.

Thus, the demographic evolution and future trends of the Setúbal Peninsula underscores its dual role as both an initial receiver of displaced urban population, but also a mirror of Lisbon's long-term infrastructural issues. While the suburban municipalities experience initial populational growth, followed by a quick wave of rejuvenation, especially between 2021 and 2031, the following decade is marked by a gradual return to aging, declining renewal, and demographic imbalance, which reinforce the importance of regional urban planning and sustainable urban policies to anticipate and mitigate these negative externalities of gentrification, while also ensuring that the suburban expansion does not simply replicate urban exclusion and the same demographic problems in other regions.

5.3. RESEARCH LIMITATIONS AND FUTURE RESEARCH

Despite acknowledging that the present research was able to produce significant and satisfying contributions, especially when considering its objectives, it is essential and natural to also acknowledge the limitations that influenced its development, and directly impacted the level of depth of the analytical framework proposed.

The primary limitation is regarding the lack of integration between the used data sources with other socioeconomic indicators associated with the gentrification phenomena, particularly those related to housing accessibility, affordability and availability. A preliminary research objective intended to combine the obtained demographic projections with real estate market data that would be retrieved from online housing and property sales platforms. However, all attempts to engage with these platforms encountered a common barrier: the absence of open-access data with sufficient quality and granularity to support a scientific and rigorous

analysis. Some of the considered platforms offered data integration services via APIs, which, in theory, would enable access to valuable datasets and allow the comparison of demographic and housing data. Nevertheless, the free versions of these APIs impose severe restrictions on both data volume and informational depth, turning their utilization unfeasible within the scope of this research, and that is a reason why it was reconsidered. Additionally, in a recall to the methodological chapter, this research adopted specific criteria for data collection, inspired by the work of Louro et al. (2021), in which the second criteria established that all data used in the research must be fully available and accessible online, without financial constraints. Thus, this study maintained a primary focus on population dynamics, respecting the methodological boundaries established.

However, despite following a different path, this scarcity of open-access data represents a significant limitation, not only for the present demographic analysis but also for a more comprehensive understanding of the infrastructures and socioeconomic dynamics that interact with the population movements studied. Nevertheless, this issue serves as a recommendation for future investigations, which given the proper resources, may integrate data from multiple paid sources, thereby fostering a combined approach that correlates demographic trends with the housing market behavior.

Another notable limitation is directly related to the availability and structure of the demographic data provided by INE, which, although offering disaggregated data related to the Census and other official sources, fails to bridge the gap regarding the interconnectivity between all the available variables and time series, which makes more complex the consolidation of more integrated analyses, with a increased number of dimensions to provide context to the population data. Unfortunately, data are frequently dispersed across independent files, necessitating intensive efforts in extraction, cleaning, and transformation to enable their coherent exploration within interactive Business Intelligence solutions like the one developed in this research.

Additionally, a third limitation arises in the context of the demographic projections. Aiming to ensure consistency in data analysis and modeling, the period between 2001 and 2021 was selected as the historical reference, as this interval provides the highest reliability and integrated availability of data across relevant dimensions (sex, age group, location), bridging the gap presented before regarding the availability of data from INE. However, for a more robust trend analysis and broader prospective outlook, extending the historical series back to at least 1991, which is, ten years backwards, would be the ideal approach, since it would allow the capturing of broader evolutionary patterns and more input information for some of the calculated rates. This temporal extension, however, was hindered once again by limitations in direct and structured access to comparable data over extended time series, but did not advance also by a methodological choice, establishing a temporal horizon of two decades of Census data for input.

Overall, most of the limitations reflect the same pattern and are related to the obtaining of data as an input for improved research. The limitations pointed out in this research reflect ongoing challenges in accessing open, up-to-date, and integrable data, especially when attempting to integrate demographic information with social and economic dimensions in a more dynamical way. Nonetheless, these obstacles did not compromise the validity of the results presented, but they rather underscore the importance and necessity of promoting greater transparency and openness in public and private data to support studies with enhanced social impact and scientific contributions.

6. CONCLUSIONS

Therefore, it can be acknowledged that this research successfully fulfilled its main purpose, providing a clear answer to the research question and all three predefined research objectives. Firstly, in a recall to the research context, it is stated in the existing literature that the city of Lisbon has been undergoing an intensive process of gentrification, which has contributed to the displacement of long-term residents and increased living costs, hardly affecting the balance between economic development and overall urban livability. Once exclusively focused on the metropolis, gentrification now expands to suburban areas, creating sub-processes of gentrification in a cascading effect. Given this context, a research gap was found in understanding to what extent are the Lisbon's gentrification-driven pressures shaping and influencing the demographic dynamics of the Setúbal Peninsula, and how to strategically measure and display the region's key demographic indicators to foresight upcoming infrastructural pressures.

Aiming to accomplish the established goals, the research followed the Design Science Research Methodology (DSRM), proposing to develop an end-to-end Business Intelligence (BI) solution that integrates historical demographic data and demographic projections to assess the spillover effects of Lisbon's gentrification. The solution followed a layered approach, integrating different Microsoft Fabric components for data ingestion, transformation, storage, and visualization, and must be considered the core artifact of this research. Also, and since one of the main objectives of this research was to conduct a foresight analysis, aiming to project future demographic dynamics and assess its impacts in the Setúbal Peninsula's demography up to 2041, the Cohort-Component Method was chosen as the core method to achieve this goal, being particularly suitable for long-term demographic projections and also internationally validated, being widely used in the field of demographic studies.

After the successful application of the Cohort-Component Method, an end-to-end Business Intelligence (BI) model was designed and implemented within the Microsoft Fabric environment, in order to achieve the research goals and better display the findings. Within the scope of DSRM, the artifact was properly evaluated taking into consideration a predefined assessment criterion, which allowed us to conclude that it met the evaluation criteria with a high level of effectiveness, providing coherent and straightforward answers to the research objectives, since it represents an interactive and analytical tool for showcasing the demographic trends and projections in the Setúbal Peninsula. Strengthened by a clean interface and flexible slicers, this tool is grounded in the display of all meaningful KPIs regarding the research topic and the three scenario-oriented projections perspective, being also open to future improvements and continuous refinement, aligning with the iterative nature of the methodology it was built upon.

Regarding the main findings that were extracted from the information presented in the developed artifact, it is important to highlight that in all the three proposed future scenarios,

the overall regional population is expected to grow in the next decade, with some slightly variances between scenarios.

At a municipality-level analysis, Lisbon demonstrates a clear trend of population aging and a decline in urban vitality across all scenarios, reflecting the impacts of gentrification in the city. The main indicators analyzed, such as the youth index, aging index, and active population renewal rate points out to a slow generational replacement and increasing dependency level of the city's population, reinforcing Lisbon's growing demographic fragility and high dependency on external migration. The population growth rate aligns with the regional trend, however, shows clear signs of future stabilization or even decline, depending on the specific scenario. Given the indicators and the trends highlighted, the moderate scenario was the one to be considered the most reliable and probable, given its alignment with the observed demographic trends and the theoretical foundations that support this research, reinforcing the continuity of populational growth for the next ten years, but assuming stabilization followed by decrease in 2041, highlighting the long-term effects of gentrification and resident population displacement.

At a regional-level analysis, and in a different path when compared to the capital, the Setúbal Peninsula shows a consistent trend of demographic growth until at least 2036, in the moderate and optimistic scenarios, reinforcing its role as an attractive suburban receiving area for populations displaced from Lisbon. Regarding the indexes, the region is following a similar populational distribution structure as Lisbon, with some special cases such as the municipalities of Almada, Moita, Montijo, and Seixal, which showcases stronger youth indices and renewal rates until 2031. Nevertheless, the aging index is expected to increase in all municipalities, a behavior that is also shared by the dependency index, which reinforces and provides evidence to the theoretical framework that indicates that the region may replicate Lisbon's demographic pressures over time, due to the suburbanization phenomena.

In terms of population growth, the observed data allowed us to confirm that the region will be acting as a receiver of displaced population for at least the next decade, overcoming the negative natural balance. Comparing the three scenarios, the most probable and consistent one was considered again the moderate one, which showed a tendency of stabilization in the growth after the next decade, since the gentrification phenomenon might reproduce new cycles of displacement and urban transformation in this receptor zones in a medium to long-term. Overall, the demographic trends in the Setúbal Peninsula will be showing signs of deceleration after 2036, precisely suggesting a saturation of absorptive capacity and growing infrastructural pressures, clearly highlighting the symptoms of a cascading gentrification effect, with the Peninsula inheriting the same issues once dominant in the city of Lisbon.

However, despite acknowledging the significant contributions of this research, some limitations impacted on its scope and analytical depth. Firstly, a primary constraint was the lack of integration between demographic data and socioeconomic indicators, especially those related to housing, which was mainly motivated by failed attempts to gather open-access data

with sufficient quality and granularity to support a scientific and rigorous analysis. Although not a decisive constraint, the scarcity of open-access data represents a significant limitation, not only for the present demographic analysis but also for a more comprehensive understanding of the infrastructures and socioeconomic dynamics that interact with the population movements studied. Nevertheless, and since DSRM is naturally iterative, this issue might possibly be mitigated by future investigations, which given the proper resources, may integrate data from multiple paid sources, thereby fostering a combined approach that correlates demographic trends with the housing market behavior. Additionally, there were also limitations related to the structure and availability of demographic data from INE, which often lacks interconnectivity across variables and time series, failing to bridge the gap between them and to allow more multidimensional analysis. Lastly, a third limitation must be recognized in the context of the demographic projections, in which even though the chosen historical window between 2001 and 2021 was able to ensure consistency, it could be extended further back to 1991, gaining one more decade of historical data to support the predictions, which is also a recommendation for future research. While these limitation clearly did not compromise the validity of the main findings, they highlight the need for greater transparency and openness in demographic data, in order to support more comprehensive and social-impactful research.

Thus, we can conclude that the developed artifact was able to generate high-level value, providing accurate and straightforward answers to the research objectives while also enabling truthful data-driven decision making in the core of the demographic field. Based on the study's main findings, the demographic evolution of the Setúbal Peninsula underscores its dual role as both a receiver of the displaced and a mirror of Lisbon's long-term infrastructural issues, reinforcing even more the importance of regional urban planning and sustainable urban policies to anticipate and mitigate these negative and inevitable externalities, ensuring an acceptable level of urban livability in the affected areas. In this way, the produced artifact may not only serve academic purposes, but also serve as a tool for data-driven urban planning in the Setúbal Peninsula.

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APPENDIX A



This is to certify that

Project No.: **GEO2025-7-36367**

Project Title: **The Spillover Effects of Lisbon's Gentrification up to 2041: Assessing Demographic Trends in the Setúbal Peninsula Through a Business Intelligence Approach**

Principal Researcher: **Bernardo Moraes Scherer**

according to the regulations of the Ethics Committee of NOVA IMS and MagIC Research Center this project was considered to meet the requirements of the NOVA IMS Internal Review Board, being considered **APPROVED** on 7/7/2025.

It is the Principal Researcher's responsibility to ensure that all researchers and stakeholders associated with this project are aware of the conditions of approval and which documents have been approved.

The Principal Researcher is required to notify the Ethics Committee, via amendment or progress report, of

- Any significant change to the project and the reason for that change;
- Any unforeseen events or unexpected developments that merit notification;
- The inability of the Principal Researcher to continue in that role or any other change in research personnel involved in the project.

Lisbon, 7/7/2025

NOVA IMS Ethics Committee
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