The inhabitants of Luxembourg: an analysis of the population over the years.

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Abstract

leave out; it is like a conference

~~This paper represents a study conducted as part of a project in the Data Sciences for Humanities course at the University of Luxembourg~~. We investigate the relationship between population growth and house prices across Luxembourg's cities and cantons, aiming to uncover the dynamics influencing these critical aspects of urban development. We use analytical Python libraries, such as Pandas, Numpy, Matplotlib and Seaborn for data processing and analysis. ~~Our findings suggest a possible correlation between the population growth and house prices over the years.~~ Our project is not finished yet. This paper is a 50% version of the final report, which will be submitted at the end of the semester.

topic: more economics, but can be seen as history too

1 Introduction

:-) Luxembourg, a small yet affluent country in the heart of Europe, has experienced significant demographic changes over the past decades. These changes have been accompanied by fluctuations in the housing market, particularly in terms of rent/house prices.

The country's unique position as a financial hub and a desirable place to live has led to ~~diverse migration patterns~~, contributing to its population growth. Concurrently, Luxembourg faces challenges related to housing affordability and availability, making this topic an import subject of study for today. This paper aims to explore the relationship between ~~population growth~~ and ~~house/rent prices~~ in Luxembourg, analysing the trends and patterns that emerge from the available data.

REF

This introduction sets the stage for a comprehensive analysis using advanced data processing and visualization tools. The findings of this study are expected to contribute valuable insights into the socio-economic fabric of Luxembourg, offering evidence-based recommendations for addressing the challenges associated with urban growth and housing affordability.

good intro; clear what you will do

2 Research Questions

Our main research question pertains to the correlation between population growth and house prices in Luxembourg. To answer this question, we will investigate the relationship between population growth and house prices over time. We will explore how changes in population density within different cantons and municipalities influence the cost of living, particularly in terms of housing.

add theory, before RQ

Primary Research Question.

1. ***Is there a correlation between rent prices and population growth in Luxembourg?*** This question aims to identify statistical relationships between the rate of population increase and the fluctuations in rent prices. By analysing these trends, we intend to reveal whether changes in population density within various cantons and municipalities directly influence the cost of living, particularly in terms of housing.

Secondary Research Question(s).

so nice maps for visualization

1. ***Does the population growth in specific areas impact rent prices?*** Beyond seeking a broad correlation, this inquiry delves into the regional nuances of the phenomenon. It recognizes that Luxembourg is composed of diverse urban and rural landscapes, each with its own economic and demographic characteristics. Understanding the localized impact of population growth on rent prices can provide deeper insights into the regional disparities within the national housing market.

To address these questions, our analysis encompasses a comprehensive review of available data sets, including migration patterns, natural population growth, and house price variations by canton and municipality. Through this examination, we aim not only to uncover the existence of a correlation but also to understand the nature and significance of these relationships.

3 Method

To address our research questions, we employ a structured methodological approach that combines data processing, analysis, visualization, and statistical techniques. The code written for this project is available on our GitHub repository.

3.1 Data Collection

these are given data sets; how did they collect? who for what purpose?

We use the following datasets for our analysis (links provided below):

1. Migration movement of the population by canton and municipality, from Luxembourg's official statistics portal.
2. Natural movement of the population by canton and municipality, from Luxembourg's official statistics portal.
3. The Prix de vente des appartements - Par commune (Price of sale of apartments - By municipality), from the Luxembourg Open Data Portal.

3.2 Data Description

Our study utilizes three pivotal datasets, each offering unique insights into Luxembourg's population dynamics and housing market. Below is a ~~description of each dataset~~ and its relevance to our study:

good

1. **Migration of Population Dataset**: This dataset provides detailed information on the migration patterns within Luxembourg, broken down by canton and municipality, over several years. It includes data on both immigration and emigration, allowing for a nuanced understanding of how population movements contribute to demographic changes across the country. Analysing this dataset will enable us to identify areas with significant population inflows or outflows and examine how these trends correlate with fluctuations in rent prices.

REFs
which org?

2. **Natural Population Growth**: The second dataset focuses on the natural growth of Luxembourg's population, again detailed by canton and municipality. It includes vital statistics such as birth rates and death rates, offering insights into the organic population growth independent of migration patterns. This dataset is crucial for understanding the underlying demographic trends that drive population changes and their potential impact on the housing market.
3. **Average Rent Prices**: The third dataset contains information on the average rent prices within Luxembourg, categorized by canton and municipality. This dataset is essential for our analysis as it provides the economic dimension of our study, allowing us to directly examine the relationship between population dynamics and housing costs. By comparing rent price trends with population growth data, we can explore whether areas experiencing population increases face corresponding rises in housing costs.

3.3 Data Cleaning and Preparation

This initial stage involved handling missing values, removing duplicates, and ensuring consistency in data formatting across all datasets.

The datasets were first imported and cleaned using the Pandas library. 2 of the datasets were stored in CSV format, while the third was in Excel format. From the 3 datasets, there were no missing values, nor duplicates. Moreover, the data was consistent across all datasets, with no formatting issues. All that was needed was to remove unnecessary columns from the datasets, that were not relevant for our analysis.

For further analysis, we combined the migration and natural movement datasets to calculate the total population change in each canton and municipality over the years. This was accomplished by summing the values of migration and natural growth for each year and location.

The house prices dataset was more difficult to handle, as that dataset was not in a format that could be easily analysed in Python. For this dataset, there was a single Excel file for each year, with the prices of each house in each municipality. We wrote a Python script to read all the Excel files and combine them into a single CSV file (Listing 1 in the Appendix). Unfortunately, this dataset does not contain the canton information, so we had to manually map each municipality to its corresponding canton in a Python dictionary (also in the script), which accounts to over 100 entries. The generated CSV file was then used for further analysis instead of the original Excel files.

3.4 Data Visualization and Analysis

Before synthesizing our findings, we begin with an individual examination of the natality, migration, and house prices datasets, each offering distinct yet interrelated perspectives on Luxembourg's development. Initially, we aim to understand each dataset individually before we proceed combining them for further analysis. This step-by-step observation sets the groundwork for revealing the complex interdependencies that shape the housing market and urban growth within the nation.

For data analysis, we use multiple Python libraries, such as Numpy, Matplotlib, and Seaborn. We start by plotting the data on each separate dataset, to understand the data better. Many of the plots are time series plots, showing the evolution of the data over the years.

After that, we combine the migration and natural movement datasets to calculate the total population change in each canton and municipality over the years. This allows us to get the bigger picture of the population growth in Luxembourg.

We then compare this data with the house prices data, to see if there was a correlation between the two. We tried plotting the number of houses sold per year, and the average price per square meter against the total population change, to see if there was a correlation between the two. We go into more detail about this in the Initial Outcomes section.

3.5 Reflection and Adaptation

We acknowledge the possibility that our initial analysis might present limitations or reveal complexities not previously considered. As such, we remain open to refining our methodological approach based on initial findings. The simplicity or complexity of the analysis will be adapted based on initial findings, ensuring that the research comprehensively addresses the posed questions while being receptive to new insights that may emerge.

4 Theory

The theoretical foundation of our project draws upon established models and empirical studies that link population growth with the housing market. This relationship is complex and multifaceted, influenced by various economic factors and policy decisions.

Building on the paper published by Landvoigt et al. [2], which examines the effect of credit market frictions on the housing market, we explore how these principles apply within the Luxembourg context.

The paper highlights the significant impact that credit access has on house prices, especially for lower-income households. By understanding the mechanics of credit allocation and house quality assignment to different demographics, we gain insight into the potential levers affecting house prices in Luxembourg.

Ali et al. [1] provide a complementary perspective by utilizing a system dynamics approach to analyse the housing market. This top-down approach, which considers birth rates, life expectancy, immigration and emigration, allows us to understand long-term market behaviour and housing demand. This paper's insights are particularly relevant for our study, given the focus on population dynamics and their influence on the housing market.

We can see that there are many factors that influence the housing market, and that the relationship between population growth and house prices is not straightforward. The theoretical approaches we have chosen to follow will help us understand this relationship better, and provide a robust framework for our study.

Our goal is to leverage these theoretical insights to better interpret our findings and to contribute to understanding the people that live in Luxembourg.

Our hypothesis is that there is a correlation between population growth and house prices in Luxembourg. We believe that as the population grows, the demand for housing will increase, which will lead to an increase in house prices. We aim to test this hypothesis through our analysis and see if our findings support it.

5 Initial Outcomes

5.1 Natality Dataset Insights

The natality dataset serves as our initial lens into the demographic shifts within Luxembourg. By tracking the rates of live births and deaths, we gain insight into the natural balance of the population—key information that influences urban development and housing market pressures.

ok

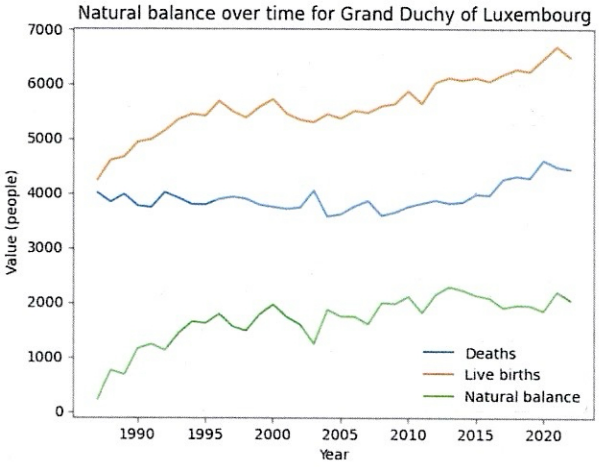


Figure 1. Time Series Analysis of Natural Balance

Graph 1: Time Series Analysis of Natural Balance. Our first graph traces the trajectory of live births, deaths, and the resultant natural balance from 1990 to approximately 2020.

- **Live Births Trend (Orange Line)**: The increasing trend in live births, especially evident since the early 2000s, suggests a burgeoning population. This rise may reflect a shift in demographic trends, potentially due to factors like an increase in the fertility rate or a growing number of families settling in the region.
- **Death Rates (Blue Line)**: The relatively steady climb in death rates aligns with an aging population but without sharp increases that would suggest demographic stress. This stability is a positive indicator of public health and contributes less dramatically to the natural population growth.
- **Natural Balance Implications (Green Line)**: The green line represents the natural balance and indicates organic growth. Its steady rise points towards a growing demand for housing, which may put upward pressure on rent prices and challenge current housing supply policies.

Graph 2: Canton-wise Natural Population Balance. Turning to the second graph, we visualize the natural population balance distributed across the cantons of Luxembourg.

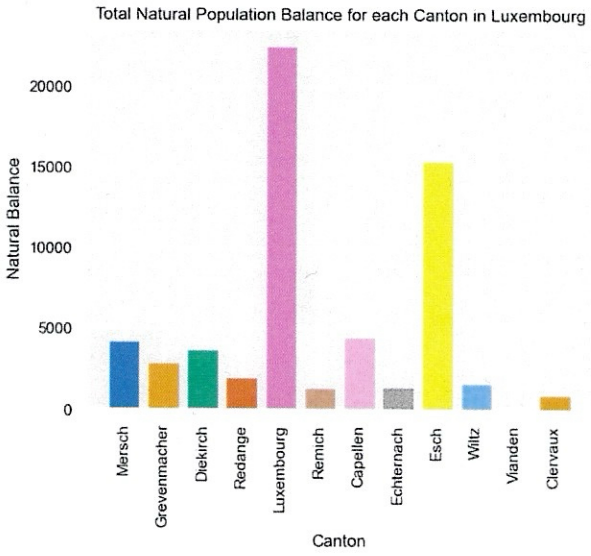
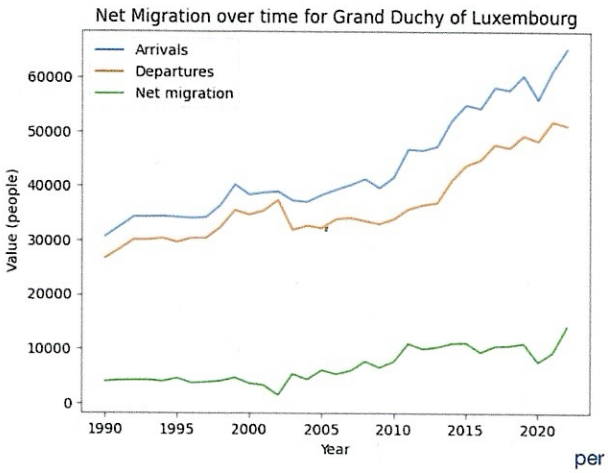


Figure 2. Canton-wise Natural Population Balance



per year?
per month?

Figure 3. Migration Trends Over Time

- **Luxembourg Canton (Purple Bar)**: Standing out with the highest natural population balance, Luxembourg Canton is likely experiencing growth that could strain existing infrastructure.
- **Esch (Yellow Bar)**: Following previous statement, it shows similar observations as Luxembourg.
- **Variation Among Cantons**: The contrast in natural population balance across cantons underscores the importance of a tailored approach to housing policy. Each canton's unique demographic profile must be considered in future urban development strategies.

These initial findings from the natality dataset underscore the varying demographic trends across Luxembourg and hint at potential future shifts in housing demand. The natural increase in population could be a driving factor in the housing market, influencing both policy and economic considerations. This analysis serves as a cornerstone for our subsequent examination of migration and house prices, providing a comprehensive perspective when these datasets are later combined.

5.2 Migration Dataset Insights

Let's delve into the migration data, which provides insights into how population movements have shaped Luxembourg over time.

Graph 1: Migration Trends Over Time. The first graph offers a time series analysis of migration from 1990 to the present.

- **Arrivals (Blue Line)**: A steadily increasing trend in arrivals suggests Luxembourg's growing attractiveness as a destination for migrants. This consistent upward trajectory may reflect the country's economic opportunities and living standards, which could influence the housing market by increasing demand.
- **Departures (Orange Line)**: The departures line shows a gentler slope compared to arrivals, indicating that while people do leave, the inflow of new residents is more significant. This net positive migration is likely contributing to the population growth and potentially putting pressure on housing resources.
- **Net Migration (Green Line)**: The net migration line illustrates the difference between arrivals and departures, displaying a generally positive increase over time. The sharp upward tilt from around 2005 onwards could indicate policy changes, an expanding economy, or other factors making Luxembourg an increasingly popular destination.

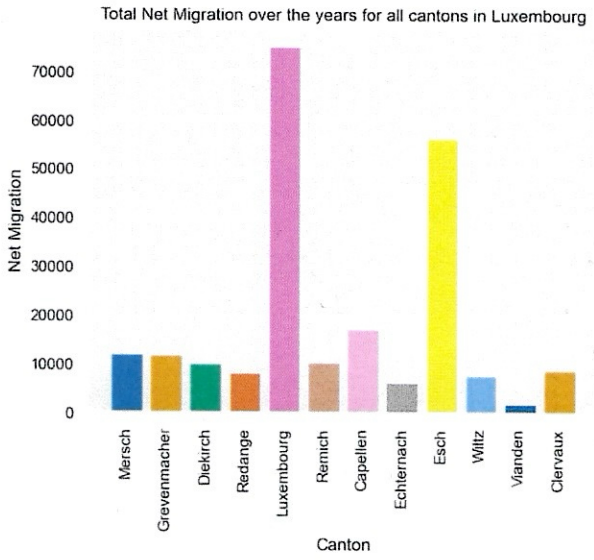


Figure 4. Net Migration by Canton

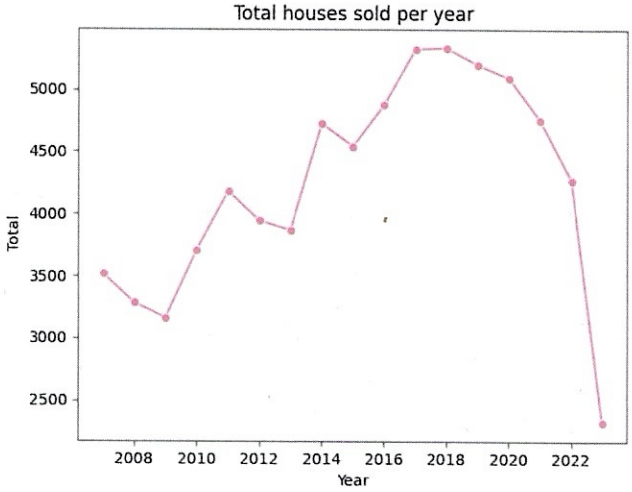
Graph 2: Net Migration by Canton. The second graph breaks down net migration across the various cantons in Luxembourg.

- **Luxembourg Canton (Purple Bar)**: Dominating the chart, Luxembourg Canton has experienced the highest net migration. This suggests a concentrated demand for housing and infrastructure, which could drive up rent prices and shape urban development.
- **Esch (Yellow Bar)**: As the canton with the second-highest net migration, Esch's housing market and urban planning efforts might also be significantly influenced by these demographic shifts.
- **Diverse Canton Dynamics**: The variability across cantons indicates that migration's impact on the housing market is not uniform. Some areas may experience more strain, while others have different levels of demand.

The data indicates sustained growth in population due to migration, particularly in certain cantons, which will need to be accounted for in housing market analyses. These trends will later be contrasted with natality and house prices to present a holistic picture of the market's dynamics.

5.3 House Pricing Insights

Analysing the house prices dataset provides critical insights into Luxembourg's housing market, revealing trends in housing affordability and reflecting the economic impact of supply and demand.



Graph 1: Total Houses Sold per Year

Graph 1: Total Houses Sold per Year. The above graph shows the total number of houses sold per year across the country provides insight into the market's liquidity and demand trends. The recent decline in sales could be indicative of various factors, including market saturation, affordability challenges, or a reaction to economic uncertainties.

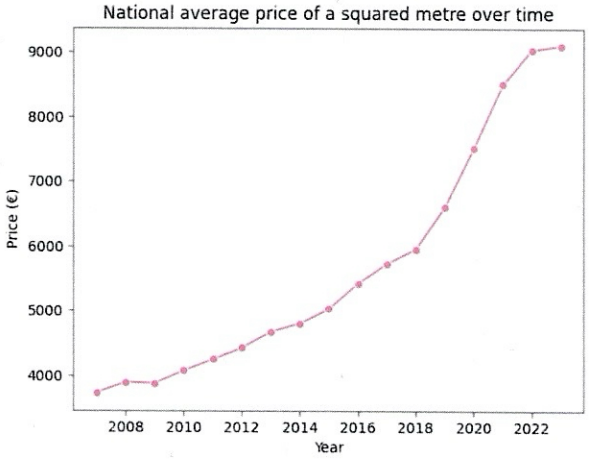


Figure 5. National Average Price per Square Meter

Graph 2: National Average Price per Square Meter. The second graph presents a national view, plotting the average price of a square meter over time. The marked rise, especially pronounced in the last few years, suggests an intensifying pressure on the housing market, potentially due to increased demand and limited supply. This escalation in prices could have significant implications for housing affordability and the socio-economic makeup of the population.

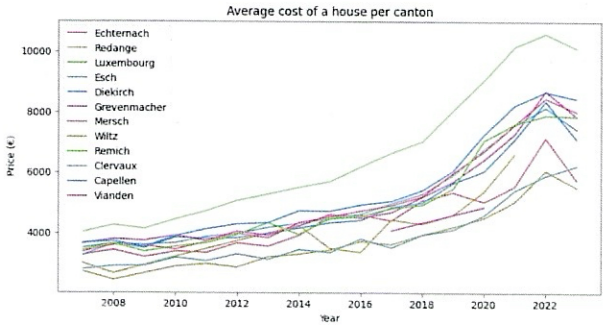


Figure 6. Average Price of a square metre Cost by Canton

Graph 3: Average House Cost by Canton. The final graph displays the average cost of a house (a square metre) in each Luxembourg canton over time. A general upward trend across all cantons is evident, indicating a nationwide increase in house prices. Some cantons, such as Luxembourg and Esch, show particularly steep increases, which may correlate with higher demand possibly driven by the natality and migration trends discussed earlier.

5.4 Initial Analysis

Upon merging the natality and migration datasets and plotted against the house prices data, we've observed intriguing patterns that inform the interplay between demographic shift and the housing market in Luxembourg.

Population and House Prices.

- **Population Growth**: The total population change, which combines natural population increase and net migration, shows a steady rise. This indicated an expanding demand base in the housing market, which, without a corresponding increase in supply, can lead to price inflation.
- **House Prices and Sales**: As we will observe in the graphs, house prices have risen consistently across cantons and nationality, with some fluctuations in the pace. Despite these rising coasts, the total number of houses sold shows a decline in recent years, suggesting a market that may be becoming less accessible due to high prices.

Analyzing Trends Across Graphs.

- **Graph Correlations**: By plotting total population change against house prices and sales, we aim to identify potential correlations. For instance, a rise in population not matched by an increase in housing sales could point towards a shortage in supply or an affordability gap.

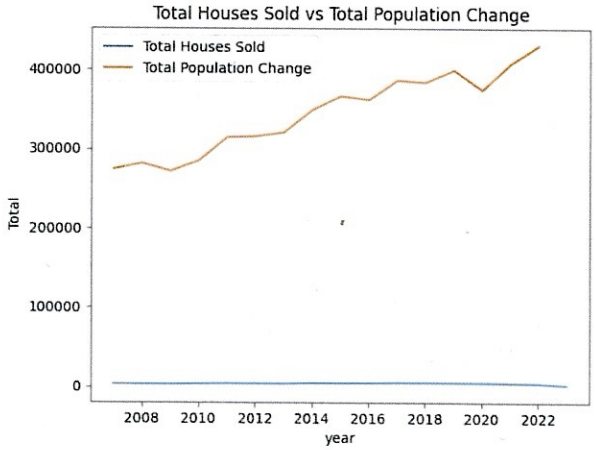


Figure 7. Linear Scale

- **Graph 1**: When looking at total houses sold versus total population change, the disconnect between a growing population and the drop in houses sold may indicate a market response to affordability or other limiting factors which are not prominent at first glance.

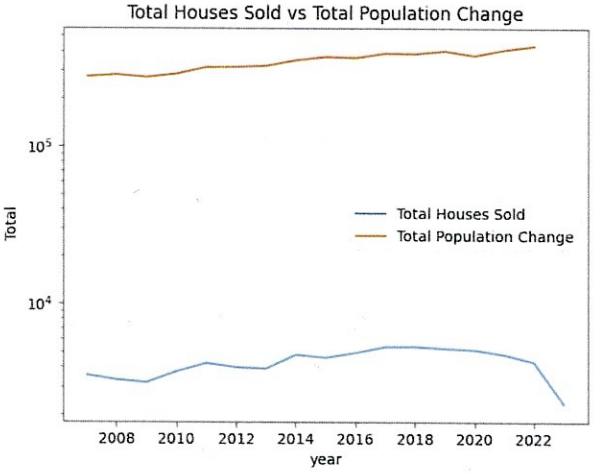


Figure 8. Logarithmic Scale

- **Graph 2**: The log-scale representation of the same data accentuates the divergence between population growth and sales volume, highlighting the nonlinear relationship and potential market constraints.

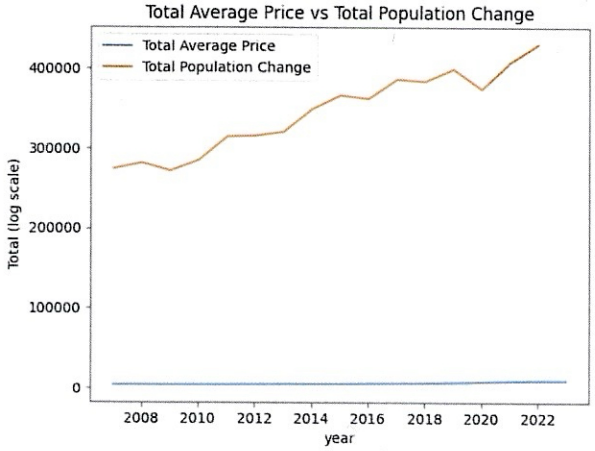


Figure 9. Linear Scale

- **Graph 3**: Through our observation, we couldn't really point out much due to the nature of linear scale, and it's lack of noticeable difference specifically to "Average Price".

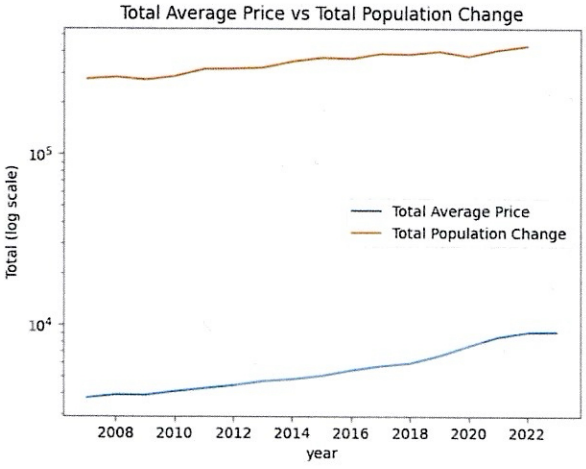


Figure 10. Logarithmic Scale

- **Graph 4**: This time around it's easier to spot changes through the log-scale. Comparing total average price to population change, the log-scale graph illuminates the escalating average prices amidst population growth. This can be interpreted as a sign of a heating market where supply struggles to keep up with the demand, which is retroactively driven by population increase.

5.5 Conclusions from the Combined Data

The analysis suggests a clear trend: as Luxembourg's population grows due to both natural increase and migration, the housing market reacts with rising prices. However, the dip in the number of transactions may hint a saturation point where buyers are either unwilling or unable to match the asking prices, possibly leading to a future cooling period or the need for market intervention.

This integrated approach provides a more comprehensive picture of the housing market, laying the groundwork for potential policy responses to ensure a balanced and accessible housing market in Luxembourg, especially in the lacking areas.

5.6 Future Work

Our initial analysis has provided valuable insights into the relationship between population growth and house prices in Luxembourg. Although, we could not yet establish a direct correlation between the two, the trends observed suggest a complex interplay of factors influencing the housing market. To further explore this relationship and address our research questions, we plan to consider other variables on the population side, such as age distribution, income levels, and household composition.

Moreover, we aim to improve this report by including more detailed statistical analyses, such as regression models, to quantify the relationship between population growth and house prices.

References

[1] Ali, G. G., El-Adaway, I. H., and Dagli, C. H. A system dynamics approach for study of population growth and the residential housing market in the us. *Procedia Computer Science 168* (2020), 154–160. "Complex Adaptive Systems"Malvern, PennsylvaniaNovember 13-15, 2019.

[2] Landvoigt, T., Piazzesi, M., and Schneider, M. The housing market(s) of san diego. *American Economic Review 105*, 4 (April 2015), 1371–1407.

[3] Ministère du Logement et de l'Aménagement du territoire - Observatoire de l'Habitat. Prix de vente des appartements - Par commune. available at: https://data.public.lu/en/datasets/prix-de-vente-des-appartements-par-commune/, 2023. [Dataset; accessed 2024-03-17].

[4] Paulo Ricardo Botelho Oliva, Adel Dedic. DS4H Project. https://github.com/Paulo-Oliva/ds4h-project. [Online; accessed 2024-04-01].

[5] STATEC. Migration movement of the population by canton and municipality. LuStat, available at: https://lustat.statec.lu/vis?lc=en&pg=0&tm=rent&df[ds]=ds-release&df[id]=DF_X025&df[ag]=LU1&df[vs]=1.0&pd=2015%2C2022&dq=..A&ly[cl]=POP_MOVEMENT&ly[rw]=SPECIFICATION&lo=1, 2023. [Dataset; accessed 2024-03-17].

[6] STATEC. Natural movement of the population by canton and municipality. LuStat, available at: https://lustat.statec.lu/vis?lc=en&pg=0&fs[0]=Topics%2C1%7CStatistics%20by%20geographical%20breakdown%23F%23%7CMunicipalities%23F2%23&fc=Topics&df[ds]=ds-release&df[id]=DF_X024&df[ag]=LU1&df[vs]=1.0&pd=2021%2C&dq=..A&ly[cl]=VARIABLE&ly[rw]=SPECIFICATION&vw=tb, 2023. [Dataset; accessed 2024-03-17].

good progress.

data sets are very useful.

continue!

4 out of 5

perhaps add the historical perspective, or the cultural importance

LiJER