M3 Challenge 2024:

A Tale of Two Crises: *The Housing Shortage and Homelessness*

TEAM #17927

March 4th, 2024

Executive Summary

To the Secretary of the UK Minister of State for Housing and Planning,

Over the last couple of years, following the COVID-19 pandemic and the subsequent economic challenges, the cost of housing crisis has quickly become one of the most prevalent issues in the United Kingdom. In the course of one year, the average monthly mortgage payments alone have risen by 25%, demonstrating how drastic the situation has become[29]. The problem of increasing homelessness, overviewed in this report to a great extent, is inextricably connected to the cost of the housing crisis, prompting us to consider how policymakers must contribute to the immediate management of the problem.

Considering historical data on the housing units in Manchester and Brighton (and Hove) over several decades, we were able to predict how the supply of housing units will change in the next 50 years using the autoregressive moving average (ARIMA) model. By plotting historical data along the predicted data, we were able to demonstrate the increasing linear trend of the housing units over time, reaching 409,363 in Manchester and 163,225 in Brighton & Hove in 2074. This model indicates that despite the evident cost of the housing crisis, the availability of housing will increase.

In a similar fashion, we were then able to model future trends in the population of homeless people based on historical data. This approach allowed us to generate three different models for Manchester and Brighton & Hove. For Manchester, we started by exploring the change in the purchasing power of the population (the ratio of median income to median property price) over time by using the power regression model, which illustrated how the purchasing power decayed over time. That model was then used to justify the predictions of the adjacent model which showed Manchester's homeless population increasing exponentially over time using exponential regression. This way, we were able to predict that in 2050 the homeless population would escalate to 24,500 compared to 12,500 in 2030. In contrast to these results, we used a similar exponential regression model to display a decrease in homelessness in Brighton & Hove over time. Hence, the population of homeless people in the city decreased from 2600 to 1400 in the same twenty-year period as in the example above.

Finally, we used these findings in the context of the issue of the cost of housing crisis, because it demonstrates how the increase in the housing prices overrides the growth of median income, leading to a net decrease in the purchasing power and therefore contributing to the escalation of homelessness in cities like Manchester. By analyzing the results, our team has identified the issue of increasing homelessness in Manchester and managed to create a solution that would effectively mitigate this issue. Our team has ensured that there is enough housing available each year, from 2019 to 2023, in Manchester, to reduce the homeless population to zero, assuming that the housing is terrace housing. This was done by researching the budget provided by the UK government for Manchester to address homelessness from 2019 to 2023. Making a second assumption that eight people will be assigned to one terrace house, the number of homeless people in those years will be multiplied by the average cost of terrace houses each year. The average cost of terrace house construction was taken as £225,30, and the chance of flooding for each building was taken as 0.223. Then, we calculated the budget required to reduce the number of homeless people to zero. Completing all these steps, our team created a model that fully achieved its purpose.

In summary, our findings identified the growing rate of homelessness in Manchester, justified by decreasing purchasing power, which was successfully mitigated by a decision to provide terrace housing. This solution for Manchester is likely to be successful because the number of available housing units is predicted to increase in both cities. Overall, our research and models show that the cost of the housing crisis in the UK can be solved and the UK Minister of State for Housing and Planning can make this come true.

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Global Assumptions

G-1. **All the houses are provided by the UK government**

- **Justification:** According to the 2022 statistics, 19% of the households in the UK belong to the private rented sector, while 17% to the social rented sector (the rest are owner-occupiers)[4]. Therefore, the difference between the housing provided by the government and the private sector is rather negligible, allowing us to assume that all the housing is provided by the UK government. Not differentiating between the two allows us to simplify our models.

G-2. **The statistics on Brighton take Hove into account**

- **Justification:** Hove is an area in Brighton, therefore all statistics on Brighton suggest similar results in regards to Hove. Thus, whenever statistics on Brighton are provided, consider them as statistics on Hove as well.

Q1: It was the best of times

1.1 Defining the problem

In this problem, we were asked to create a model that predicts changes in the housing supply in Manchester, and Brighton and Hove in the next 10, 20, and 50 years. Our model takes into consideration the housing units over a set period of time and ignores differences in the housing types due to the unrealistic results they produce.

1.2 Assumptions

1-1. **The inflation rate and UK economy are not taken into account**

- **Justification:** This assumption was created for the purposes of simplification. The historical data used in the creation of the model takes inflation into consideration. Therefore, there is no need to make inflation a separate variable, etc.

1-2**. The housing supply suggests both public and private sector housing**

- **Justification:** It is difficult to differentiate between private and public sector housing in the context of the model; therefore, for the purposes of simplicity, we did not consider the differences between the two in our model.

1-3**. There will be no advancement in construction techniques**

- **Justification:** Because the range of years asked is very large there is likely to be a lot of advancement, it was said that in 2024, the UK construction industry is expected to fully embrace advanced technologies[8], and the data provided only reaches up to 2022. Therefore there will be variations that would be hard to predict, so the model would assume the same trend followed before 2022.

1.3 Variables

Symbol	Definition	Units
Y	The year considered	years
H_M	Housing of all types in Manchester	Housing units
H_B	Housing of all types in Brighton	Housing units

Table 1: Variable definitions for Problem 1

1.4 Developing the Model

To predict the changes in the housing supply (in housing units) over the span of 50 years in Brighton and Hove, and Manchester, the autoregressive integrated moving average (ARIMA) was used via MATLAB software. It is a statistical analysis model specifically designated to predicting future trends based on past values (historical data)[5]. Our reason for choosing ARIMA is firstly because it solely requires historical data and therefore did not require additional research. Utilizing ARIMA allowed us to take advantage of all the data that was provided to us in abundance. Secondly, ARIMA is based on autocorrelation, which shows how each time series observation relates to the past[6]. We have relied on the exact same method in our predictions; thus, it was sensible to use a mathematical model that already followed the selected approach. Furthermore, the ARIMA model is often used in the real estate industry (e.g., in the estimation of the market value), and can therefore be easily applied to the situation in this problem[7]. The underlying issue of using ARIMA for this model is the fact that it is not typically used for long-term forecasting, especially for such intervals as 50 years. Nevertheless, the trend predicted by this particular model is unlikely to be affected by certain factors like human thinking which would have had a substantial impact in the case of a finance study for example, where ARIMA is often used.

The ARIMA model typically includes the following parameters: p d, and q. The p parameter is the lag order - the number of lag observations (fixed amounts of passing time) in the model[9][5]. Parameter d is the degree of differencing or the number of times the raw observations are differenced, which is done by taking input source data and target data to produce difference data so that the source and the difference data can reconstruct target data [5][10]. Parameter q is the order of the moving average which calculates the average of a selected range of values by the number of periods in that range, which in turn describes the size of the moving average window[11][5].

Our team used polynomial regression to display the prediction of the relationship between the year and the number of housing units of each type of housing. The (x) variable on the graph represents the year (from 1993 to 2043); the (y) variable represents the housing units (for all types). The graph demonstrates the sum of data on all housing units and predicts its change over time. The reason we decided to not generate predictions for all types of housing (e.g., bungalow, terrace, detached, etc.), is because the model ends up producing unrealistic results. When all housing types are considered, the curve spikes exponentially. Moreover, when polynomial settings are used, the curve can be negative and will have minima and maxima regardless, which is not appropriate for the prediction trend of this model. In regards to economic factors, we have decided not to include the inflation rate in the model because its percentage was already incorporated into the historical data of housing, and therefore has been considered in the model indirectly. Lastly, we have decided to not differentiate between private and public housing sectors in our variables because it was difficult to incorporate them into the model;

hence, we have omitted this variation for the sake of simplicity. In a similar fashion, the model will not consider the advancements in the construction sector.

The Manchester model:

$$H_M = 16.3015 \times Y^2 - 63502 \times Y + 61992000$$

The Brighton & Hove model:

$$H_B = 601.0246 \times Y - 1083300$$

1.5 Results

The model shows how the housing supply in Manchester and Brighton (and Hove) changed in the span of 50 years.

<u>Graph for Manchester</u>**:**

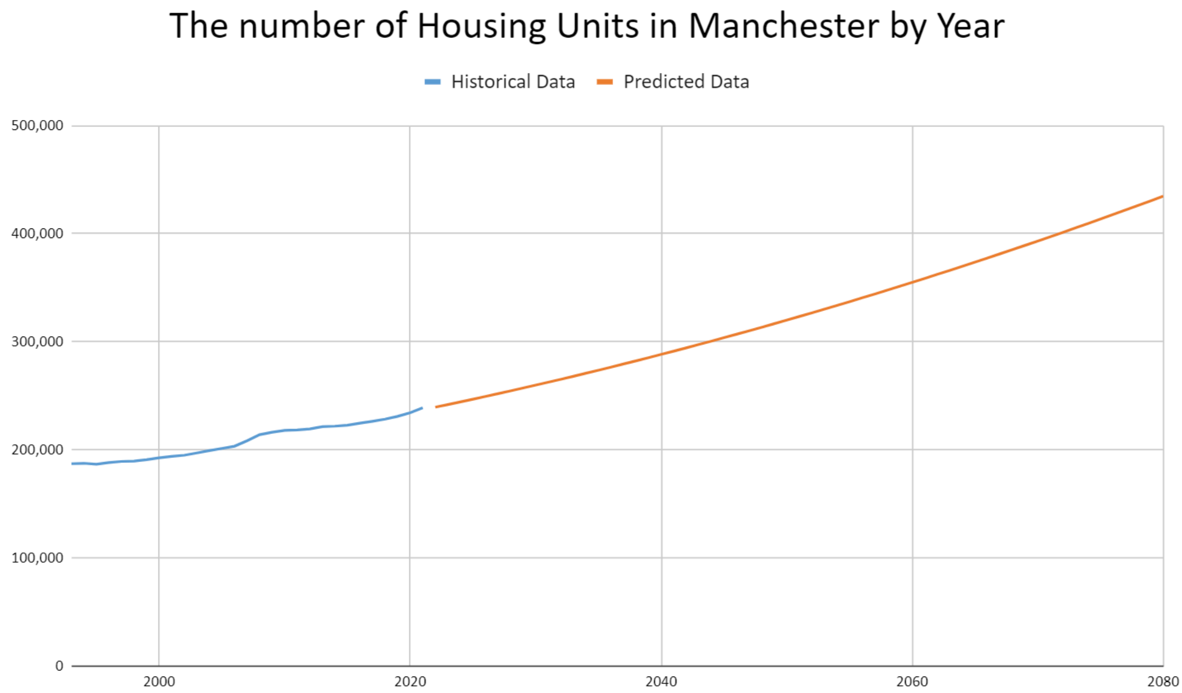

Figure 1: Graph of historical and predicted values for housing units in Manchester through 2080

<u>Graph for Brighton & Hove</u>:

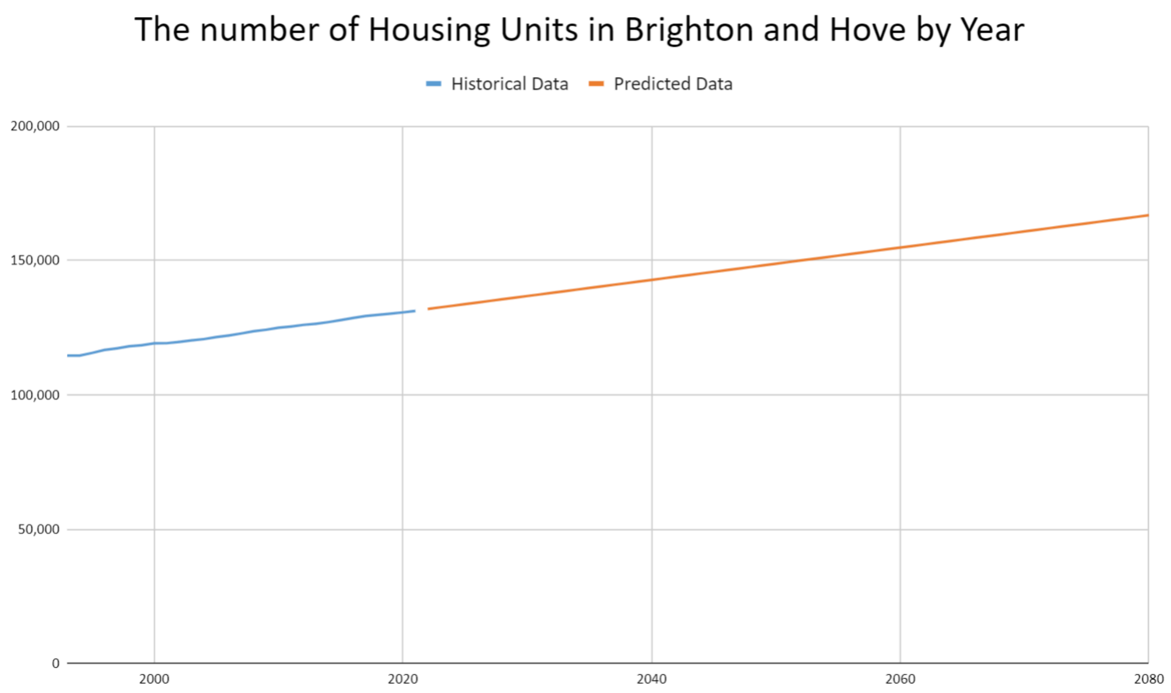

Figure 2: Graph of historical and predicted values for housing units in Brighton through 2080

On the graph above, the historical data is displayed in blue and predicted in orange. The software used for generating and solving the equation was MATLAB. The function provided demonstrates an evaluation of the situation over the course of 50 years, and therefore considers a variety of scenarios. The precise results for the question asked are displayed below:

Year	Manchester	Brighton & Hove
2034	270,781	139,184
2044	300,536	145,194
2074	409,363	163,225

Table 2: Projected numbers of housing units in Manchester and Brighton in 10, 20, and 50 years

For both Manchester and Brighton (and Hove) we can see there is predicted to be a growing increase in the number of housing units as each year passes. We are quite confident in the accuracy of our results because, as will be discussed later, the models have a decent accuracy.

1.6 Discussion

The general trend observed on the graph is a linear increase, revealing an increase in the number of housing units per year. Therefore, the model allows us to conclude that the housing supply will increase annually in both Brighton (and Hove) and Manchester. Hence, the model reveals that despite factors like homelessness and the increasing cost of housing, the availability of housing will increase over a fixed period of time.

1.7 Sensitivity Analysis

We performed a sensitivity analysis in order to estimate the accuracy of our forecasts. It was done by applying our models for both regions to past years and then comparing them to the actual data values. The method we used is percentage error (P.E.), which shows how far from the real value our prediction is.

$$P.\ E. \ = \frac{|predicted - actual|}{actual} \times 100\%$$

We calculated percentage errors for the years 1993 to 2021, and the mean P.E. for our forecasts for the future was decided to be the mean of those. Below are the obtained results.

Measurement \ City	Manchester	Brighton & Hove
Estimated Percentage Error for the Future	**0.989%**	**0.186%**

Table 3: Estimated Percentage Error for the future predictions

Both percentage errors are less than 1%, with Brighton & Hove having an incredibly high accuracy. This indicates that the models applied predict very close values to those from the historical data, and it potentially forecast the future with high accuracy. Thus, we are confident that it is realistic and reliable to a great extent.

1.8 Strengths & Weaknesses

<u>Strengths</u>

The strength of the model is that the percentage errors are less than 1% which shows a high accuracy. The data provided also fits well with the data model made. This means that predictions should be highly accurate. Furthermore, the model takes a more representative approach of the whole housing units against years making it easier to work with the data.

Due to the relative simplicity of the graphs for both Manchester and Brighton and Hove, it may be easier to use the graph and data points for further calculations and analysis.

<u>Weaknesses</u>

The weakness of the model is that it does not display how the housing supply changes according to its type. The model produced unrealistic results when the housing type was considered; therefore if we had the time and resources to continue working on the model we would have found a way to modify the model by producing separate models for each housing type as the housing types do not directly correlate with each other on an individual scale but on the whole produces an accurate graph.

This would allow us to take the type of housing into consideration and produce more relevant results. Furthermore, this would have also given us greater insight into the distribution of housing types which would have produced more accurate results in turn.

Q2: It Was the Worst of Times

2.1 Defining the problem

The second problem asks us to predict changes in the homeless population in the next 10, 20, and 50 years for Manchester and Brighton (and Hove). The problem requires additional research on the rates of homelessness in both cities as well as consideration of factors that might affect it (e.g., the purchasing power expressed in the ratio of mean income over the housing prices).

2.2 Assumptions

2-1. **The population of Manchester will be increasing linearly**

- **Justification:** According to the data provided by the Mathworks Math Modeling Challenge, the population will continue to grow in a linear trend[1][4].

2-2. **The population of Brighton and Hove will be increasing linearly**

- **Justification:** The population will continue to grow[2], and based on the data provided by the Mathworks Math Modeling Challenge[1], the population has a slow and steady increase.

2-3. **People renting should not be accounted for**

- **Justification:** People who own a house and homeless form a whole population

2-4. **The UK government and city councils' homelessness management strategies do not produce considerable results (via social programs, etc)**

- **Justification:** Homelessness management strategies may affect the population of homeless people. For simplicity, this factor is omitted.

2-6. **People eligible for government homelessness relief duty but have a home would be considered homeless**

- **Justification:** Homelessness can be defined as when an individual lacks a fixed, regular, and adequate nighttime residence[12]. People who usually fall under this category are either in a bad, unstable house or are about to become homeless.

2-7. **Assume that both 'priority need' and 'not priority need' are equally important**

- **Justification:** both are considered homeless and therefore make up a single variable

2-9. **Data on the homeless population in 2020, 2021, and 2022 with the exception of the Brighton model is omitted due to the effects of COVID-19**

- **Justification: The** COVID-19 pandemic has significantly contributed to the increase in homelessness, affecting over 130,000 households in the UK[18]. Therefore, these two values can be considered outliers because the data was affected by extreme circumstances.

2.3 Variables

Symbol	**Definition**	**Units**
Y	The year considered	years
H_M	Homeless people in Manchester	people
H_B	Homeless people in Brighton & Hove	people

Table 4: Variable definitions for Problem 2

2.4 The Model

2.4.1 The Model for Manchester

One of the limitations of the data provided by the Mathworks Math Modeling Challenge[1] was insufficient data on the homeless population in each city over time. Therefore, we started with searching for data on the homeless population in Manchester by year (historical data) to then create a prediction for the future trend in homelessness. However, one of the emerging limitations of our model was insufficient (absent) data on the population of unhoused people for years 2016 and earlier in both cities. Nevertheless, it is noteworthy that we deliberately did not consider the homeless population in the years affected by COVID-19, which are 2020, 2021, and 2022, as it was mentioned in the assumptions above. The data points gathered via research of outside sources are displayed in the table below:

Year	**Homeless population (people)**
2017	3486
2018	4005
2019	5352
2023	7407

Table 5: Homeless population in Manchester by Year

To plot the predictions to illustrate the trend in homelessness over time, we decided to implement the power regression model for reasons that will be discussed in the sections below. The software used for this problem includes Google Spreadsheets and MATLAB. The graph produced is displayed below.

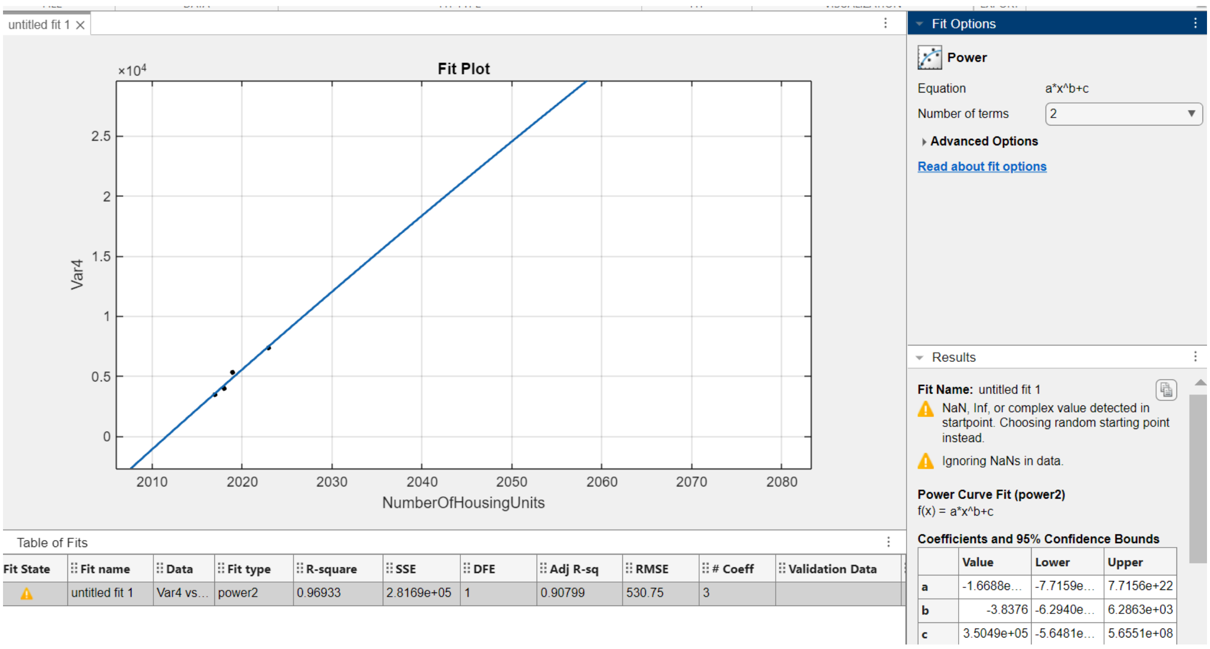

Figure 3: The homeless population against time in Manchester

Despite having insufficient data for predicting the future of homelessness in Manchester, we concentrated on ensuring that the pattern of homelessness is predicted correctly and is consistent throughout the period by using a power regression model. Using a power regression model provided us with flexibility in fitting data that did not conform to linear patterns. This way, it accommodated the rate of change of one variable that was roughly proportional to the power of the other variable.

For the second model overviewed below, we used the ratio of median income to housing prices (to indicate the purchasing power) in order to find the correlation between the homeless population and the purchasing power to afford housing. We plotted the graph of the ratio of median income to median house price against time using the exponential regression model.

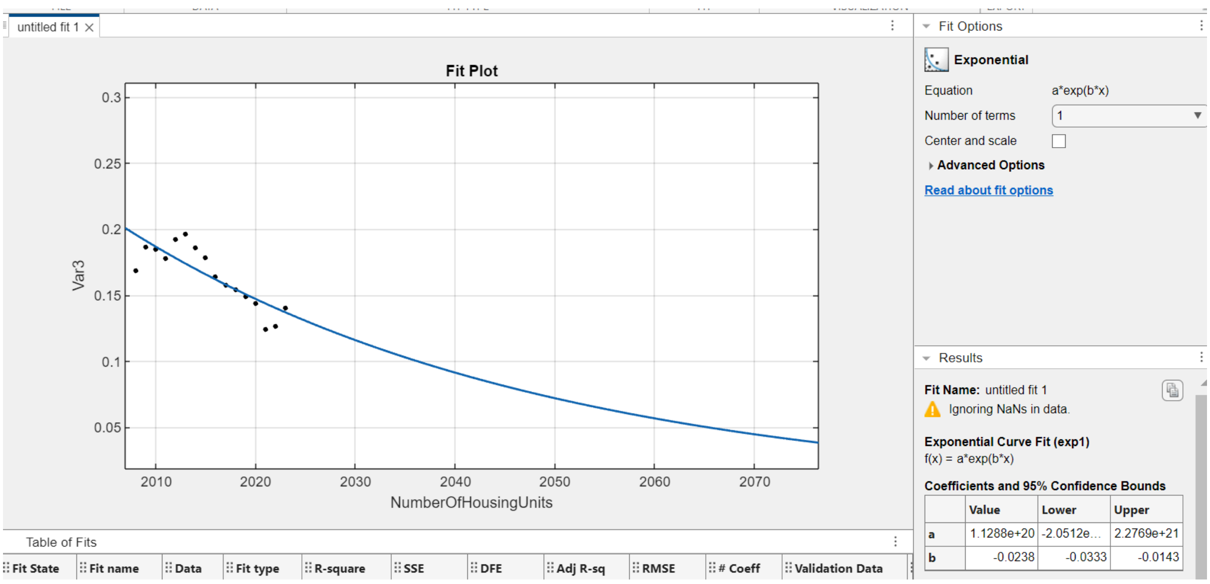

Figure 4: The ratio of median income to median housing price against time in Manchester

This model was used to support and justify the predictions of our primary model (showing growth in the homeless population). Exponential regression used in this model is typically used for modeling situations where a decrease in data is rapid at first and then that gradient steepness decreases. Exponential regression is useful for this scenario because the overall trend demonstrated is a decline, and the exponential model approaches zero slowly, however, never reaching it. Whereas other regressions such as logistic regression or linear regression approach zero much sooner. The fact of plotting this graph allowed for an understanding that the lower the ratio of median income to median house price is, the fewer people are able to purchase a house. Hence, more people will become homeless. And this ratio decreases over the years, the homelessness population has to increase. Regarding the plotting of the actual graph of the homeless population against time, we had three options that all demonstrate growth for the population of homeless people, which are exponential regression, linear regression, and power regression. After some research and analysis, we ultimately chose the power regression model because as can be seen in (Figure 4), the graph starts to level off and therefore the rate of increase of the homeless population will slowly start to decrease over time which is not seen in linear regression and exponential regression. Moreover, exponential regression shows a sharp increase in the homeless population after a couple of decades, which then leads to completely unrealistic outcomes.

Equation of the model for Manchester:

$$H_M = -1.6688 \times 10^{18} \times Y^{-3.8376} + 350490$$

The graph of the ratio of median income to median household prices (y-axis) against years (x-axis) justifies the model we have used. The graph shows there is a correlation between the ratio of median income to household prices and homelessness over the years. When the ratio of median income to household prices decreases, the number of homeless people increases.

The assumptions created for this problem included a linear increase in the populations in Manchester and Brighton and Hove, considering that the populations had increasing trends according to historical data[1]

2.4.2 The Model for Brighton & Hove

We started by searching for data on the homeless population in Brighton & Hove by year to then create a prediction for the future trend in homelessness. However, as with Manchester, one of the limitations of our model was insufficient (absent) data on the population of unhoused people for years 2016 and earlier. The data points gathered via research from outside sources are displayed below.

Year	Homeless population (people)
2017	4050
2021	3735
2022	3575

2023	3155

Table 6: Homeless population in Brighton & Hove by Year

Initially, we wanted to approach this problem for this region in the same way, however when researching the values of the homeless population, there was a decrease over the years, yet the graph of the ratio of median income to median housing price against time in Brighton & Hove decreased over time, like in Manchester. This is likely due to the actions taken by the Brighton and Hove City Council to reduce homelessness[27].

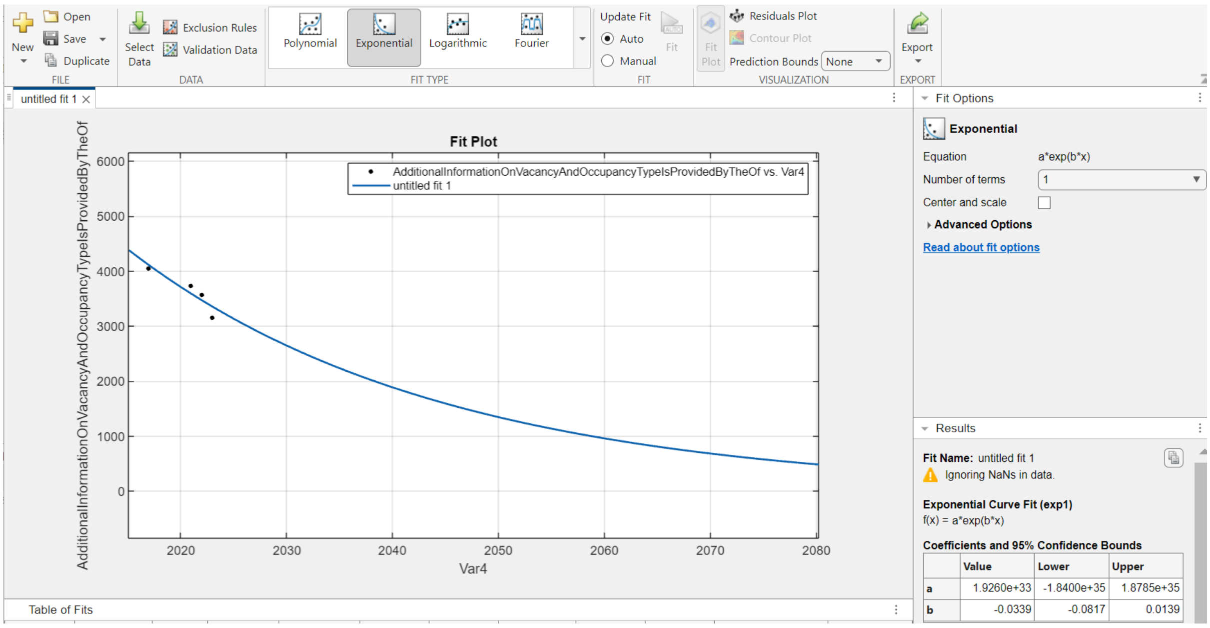

Figure 5: the Homeless Population against Time in Brighton & Hove

The reason for the exponential regression choice is the same as the previous time. It represents a decrease in data that is rapid at first and then that gradient steepness decreases. Exponential regression is useful for this scenario because the overall trend here is a decline, but the exponential model approaches 0 slowly, but does not reach it.

Equation of the model for Brighton & Hove:

$$H_B = 1.9260 \times 10^{33} \times e^{(-0.0339 \times Y)}$$

2.5 Results

The models displayed above answer the question asked by showcasing how the population of homeless people changes in both cities in the span of 50 years (therefore considering a variety of scenarios). The sample of precise results for the question asked is displayed in the table below: Manchester demonstrates a general increase in the population of homeless people, while Brighton & Hove shows a general decrease.

Year	Manchester homeless population	Brighton & Hove homeless population
2034	14538	2182
2044	20802	1555
2074	38731	562

Table 7: Projected Homeless population in Manchester and Brighton & Hove in the next 10, 20, and 50 years

The equation above was generated by plotting historical data along with predicted data against time to create an exponential decay model for the decreasing homeless population in Brighton. The equation was generated using a combination of Google spreadsheets and the MATLAB software.

2.6 Discussion

The prediction reveals that the Manchester homeless population will be rapidly increasing over a long period of time and some action would be required to be taken in order to deal with this problem. On the other hand, there is predicted to be a steady decrease in homelessness in Brighton and Hove, which indicates that successful control was taken over the homeless people in Brighton & Hove, highlighting an indication that the local councils and societies recognize the importance of the problem.

2.7 Sensitivity Analysis

We performed a sensitivity analysis in order to estimate the accuracy of our forecasts. It was done by applying our models for both regions to past years and then comparing them to the actual data values. The method we used is percentage error (P.E.), which shows how far from the real value our prediction is.

$$P.\ E.\ = \frac{|predicted - actual|}{actual} \times 100\%$$

We calculated percentage errors for the years 2017 to 2023 with the exception of 2020, 2021, and 2022 due to COVID-19 in Manchester and 2017 as well as 2021-2023 for Brighton, and the mean P.E. for our forecasts for the future was decided to be the mean of those. Below are the obtained results.

Measurement \ City	Manchester	Brighton & Hove
Estimated Percentage Error for the Future	**4.152%**	**5.518%**

Table 3: Estimated Percentage Error for the future predictions

Both percentage errors are relatively low, with Manchester having a percentage error of less than 5%. This indicates that the models applied predict close values to those from the historical data, and it potentially forecasts the future with relatively high accuracy. Thus, we are confident that it is realistic and reliable to a great extent. Although, with bigger values, 5% may hold a significant impact on the predictions. This may be a result of COVID-19 in Brighton causing higher inaccuracy as 2021 and 2022 were taken into account.

2.8 Strengths & Weaknesses

Strengths

The power regression model we used to model the trend of homelessness in Manchester and Brighton was still able to predict a pretty accurate assumption regardless of having insufficient data on the population of homeless people in both cities (Manchester especially).

Weakness

We could not find a homeless population before 2017 in either of the cities - insufficient data. Therefore, we do not know if the data used could be considered as outliers. Therefore, it is important to note that it is unlikely to obtain clear-cut values that we can use to predict the future. Data research is only provided with years within the last 8 years, therefore we cannot take into consideration what the past data would be like, thus our assumption that the values may be increasing or decreasing over the years could be false. Furthermore, the percentage errors reached 5% which is significantly higher than that of question 1 and may have effects on the data predicted.

Q3: Rising from This Abyss

3.1 Defining the problem

In this question, our team had to consider our results from the first two questions for Manchester, to create a model that would help to determine a long-term plan to address homelessness. We ensured that our model is adaptable to unforeseen circumstances like natural disasters and economic recessions.

3.2 Assumptions

3-1. **The migration rate will be constant over the next 50 years and will not be a separate variable**

- **Justification:** The migration rate is accounted for as part of the total population of Manchester.

3-2. **Assume natural disasters occur in Manchester (e.g., flooding) with 22.3% of houses being damaged**

- **Justification:** There are no significant natural disasters in Manchester except for flooding. According to the Manchester City Council[30][31], there are around 215,000 households overall, of which around 48,000 are at medium or high risk of flooding. This means that approximately 22.3% of houses can possibly be damaged.

3-3. **Assume all houses built are small terrace housing units**

- **Justification:** Are easy to build and they can be built fairly quickly in large quantities, therefore can be done in a short period of time, thus whenever natural disasters or collapse of buildings occur, properties can be rebuilt without a long wait time.

3-4. **Assume that each terrace house can fit 8 homeless people**

- **Justification:** An average terrace house is a 5m x 5m house with 2 floors, with 4 rooms. Two homeless people can fit into 1 room comfortably with the right equipment.

3-5. **Assume all terrace houses are insulated**

- **Justification:** The material used to build the house provides enough insulation, and heating doesn't have to be factored into the equation

3-6. **Assume that migration falls under the category of population growth**

- **Justification:** We can assume that the migrants add up to the current population of Manchester as they are residing in the city[33].

3-7. **Assume the maximum amount of money given to homelessness in Manchester is 150 million**

- **Justification:** The government would not provide a huge amount of money just for a city such as Manchester, so it is safe to assume that there is a maximum amount of money that we can receive

3-8. **Assume after every decade there is an economic recession which drops the budget by 5%**

- **Justification:** This trend in recessions is observed often enough to assume it will be true for this model[34].

3-9. **Assume the probability of house flooding is constant over the years**

- **Justification:** Although climate change affects the chance of flood, it will not increase substantially over the years. Moreover, this assumption will simplify the model.

3-10. **Assume that the cost of the terrace house is the same from 2022 onwards**

- **Justification:** We cannot predict the rate of inflation that will occur in the future so the assumption made is that the price would remain the same for our model to function

3-11 **All houses that are provided by government are occupied**

- **Justification:** people residing in them are not considered homeless as they have their necessities met

3.3 Variables

Symbol	**Definition**	**Units**
Y	The year considered	years
N_{TN}	The number of terrace houses needed for all of the	house
H	Homeless population in Manchester	people
P_F	Probability of flooding to occur which will damage the property	percentage
C_T	A cost of building one terrace house	Thousands of pounds

B_P	The budget for the considered year that can be provided by the government for this	Millions of pounds
B_N	The budget for the considered year that is required to have no homeless people	Millions of pounds

Table 8: Variable definitions for Problem 3

3.4 The Model

Data gathered:

Year	Homeless Population	Number of terrace house needed to fit eveone	Money required for all those houses needed	Budget for homeless people spent by the government (£)	Average unit cost of terrace houses
2017	3,486	436			
2018	4,005	501			
2019	5,352	669	115454013	1940000	172,577
2020	5,885	736	139620153.8	3860000	189,798
2021	6,798	850	168230955.8	27500000	197,977
2022	7,689	961	216546268.1	28450000	225,305
2023	7,407	926	210598601.6	44000000	227,459

Table 9: Gathered data for problem 3

We took the number of homeless people from 2019 to 2023, assuming that eight people will be assigned to one terrace house. After that, we compiled the number of terrace houses that need to be built in order to decrease the population of homeless people to zero each year from 2019 to 2023.

$$N_{TN} = H \div 8$$

The average cost of terrace house construction was taken as £225,300[35], and the chance of flooding (P_F) for each building was taken as 0.223, as explained in the assumption above. Then, we calculate the amount of money required to have no homeless people each year.

$$B_N = N_{TN} \times C_T$$

We researched the budget provided by the UK government for Manchester for homelessness from 2019 to 2023.

$$B_P = (1.0871 \times 10^7) \times Y - 2.1949 \times 10^{10}$$

We coded the program, taking 2022 as our start year. And the model runs a loop until a year when the total number of houses already built is more or equal to the required number, taking into account the growth of population, homeless population, and government budget.

Following the annual budget provided to the homeless [10]

3.5 Results

The results obtained by the program. produced a result indicating that in the year 2028, the homelessness of Manchester can be resolved. Using our model, comparing the yearly budget to the amount of years available, we developed a model that was able to resolve homelessness within Manchester by 2028. Our model can be a reference to mitigate the growing population of homeless and effectively address this issue permanently.

3.6 Discussion

The reason we picked Manchester over Brighton & Hove is that the rate of homelessness in Brighton is decreasing due to numerous actions being taken by the government and independent parties[27]. The increasing rate of homelessness was indicative of a problem, likely caused by the cost of the housing crisis - a major problem the UK is trying to mitigate at the moment. In addition to that, the data on homelessness and its management was much more abundant and accessible in Manchester than in Brighton & Hove.

3.7 Strengths & Weaknesses

Strengths

The model used takes into account the flooding that occurs in Manchester which does have an effect on the property built. Taking into consideration that flooding occurs somewhat often (22.3%), the model allows us to calculate how many houses are needed to be repaired. The budget necessary to repair the houses is taken from the annual budget provided by the government ($B_{P.}$). The model also takes into consideration the growing homeless population

Weaknesses

The model used has flaws such as not considering the inflation of prices and also did not take into account things such as economic recessions. This can be fatal in our assumption as we are not able to give an accurate assumption if the inflation prices are too high or if there is a crash in the economy. Geographical location and position of houses have not been considered, as we assumed every house is the same price.

Conclusions

In the first question, our team implemented the ARIMA model to predict how the housing supply in Manchester and Brighton & Hove will change over the 10, 20, and 50 years based on the historical data from the 1990s to late 2020s. For Manchester, our model predicted that the number of housing units will increase from 200,400 in 2020 to 200,600 in 2030, to 200,900 in 2040, and 300,900 in 2070, suggesting a roughly linear relationship. Similarly, in Brighton, the housing supply increased from 135,000 in 2020 to 140,000 in 2030, 145,000 in 2040, and 165,000 in 2070, likewise illustrating a linear increase with a lower gradient. Then, our team created three models to predict the trend in homelessness in the two cities over time. For Manchester, we used the exponential regression to illustrate the decrease in purchasing power (ratio of median income over housing price) over time, along with the power regression model to predict an increase in the homeless population over time. For Brighton, the exponential regression model was used to show an exponential decrease in the population of homeless people. The model of decreasing the purchasing power of people in Manchester was created to justify the adjacent model of increasing the homeless population in the city. This way, our team has identified the issue of increasing homelessness in Manchester in Question 2, which we then addressed in Question 3 by creating a solution that would mitigate this issue effectively. We approached this problem by ensuring that there is enough housing available each year in Manchester to reduce the homeless population to zero. This was done by researching the budget provided by the UK government for Manchester to address homelessness from 2019 to 2023. Assuming that the type of housing is a terrace and that eight people will be assigned to one terrace house, we took the number of homeless people in those years and multiplied it by the average cost of terrace houses each year. This way, our team has successfully managed to decrease the population of homeless people in Manchester to zero each year from 2019 to 2023.

In summary, our findings suggest that the growing rate of homelessness in Manchester, justified by decreasing purchasing power, can be mitigated by providing terrace housing. This solution for Manchester is likely to be successful because, as Question 1 has shown, the number of available housing units is supposed to increase in both cities. Meanwhile, the trend of homelessness in Brighton has been decreasing annually, which could potentially be linked to the increased availability of housing each year. Overall, our research and models show that the cost of the housing crisis is not a permanent issue and the UK Minister of State for Housing and Planning has the opportunity to address the issue effectively.

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36.

Code Appendix

Q3)

```
import numpy as np



# stuff to consider
```

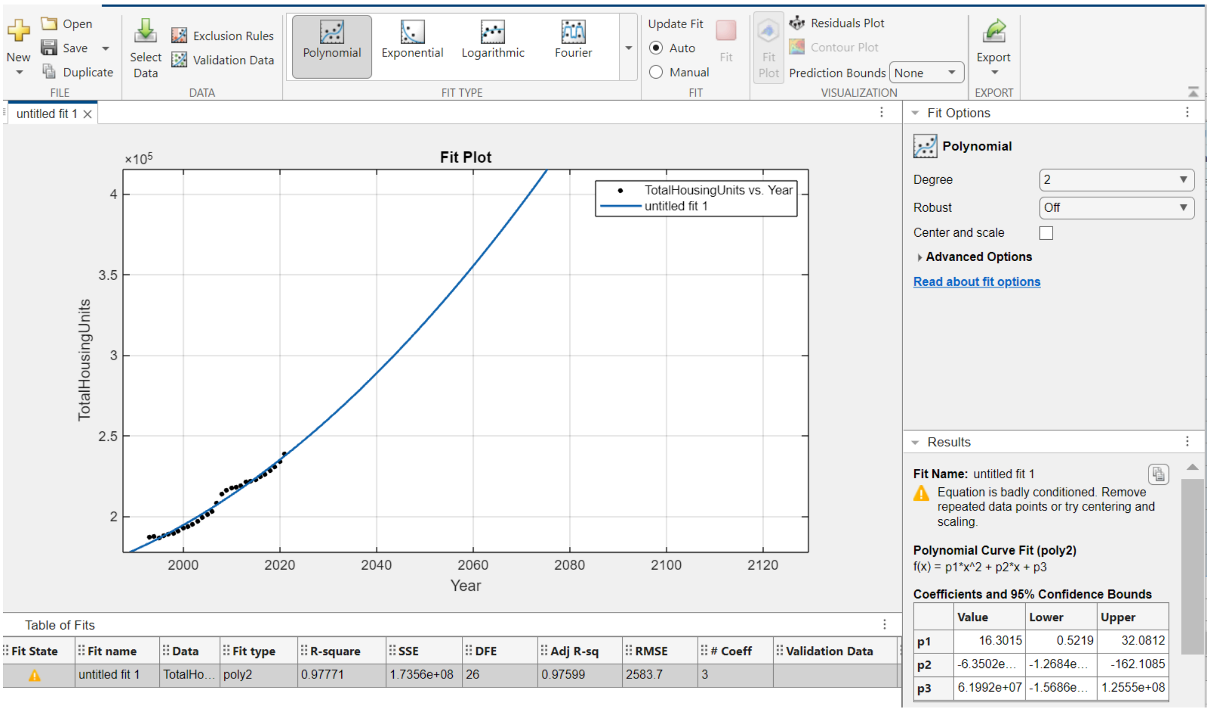
```
flood_damage_rate = 0.223

repair_cost_per_house = 20000

people_per_house = 8



# taken from question 2

def predict_homeless_population(year):

    return -1.6688 * (10**18) * year**(-3.8376) + 350490




def houses_needed(population):

    houses_needed = np.ceil(population / people_per_house)

    return houses_needed*(1 + flood_damage_rate)




start_year = 2022

# summing all the households provided for homeless people in 2022

current_houses = 0

budget_1 = 28450000

terrace_house_cost = 225305



def new_budget(year):
```

```
    return 1.0871 * (10**7) * (year) - 2.1949 * (10**10)



year = start_year

while True:

    population = predict_homeless_population(year)

    needed_houses = houses_needed(population)

    budget_2 = new_budget(year)



    repair_cost = current_houses * flood_damage_rate *
repair_cost_per_house

    available_budget = budget_2 - repair_cost



    new_houses_built = np.floor(available_budget/ terrace_house_cost)

    current_houses += new_houses_built



    if current_houses >= needed_houses:

        break



    year += 1



print(f"The year when there are enough houses for all homeless people
is: {year}")
```

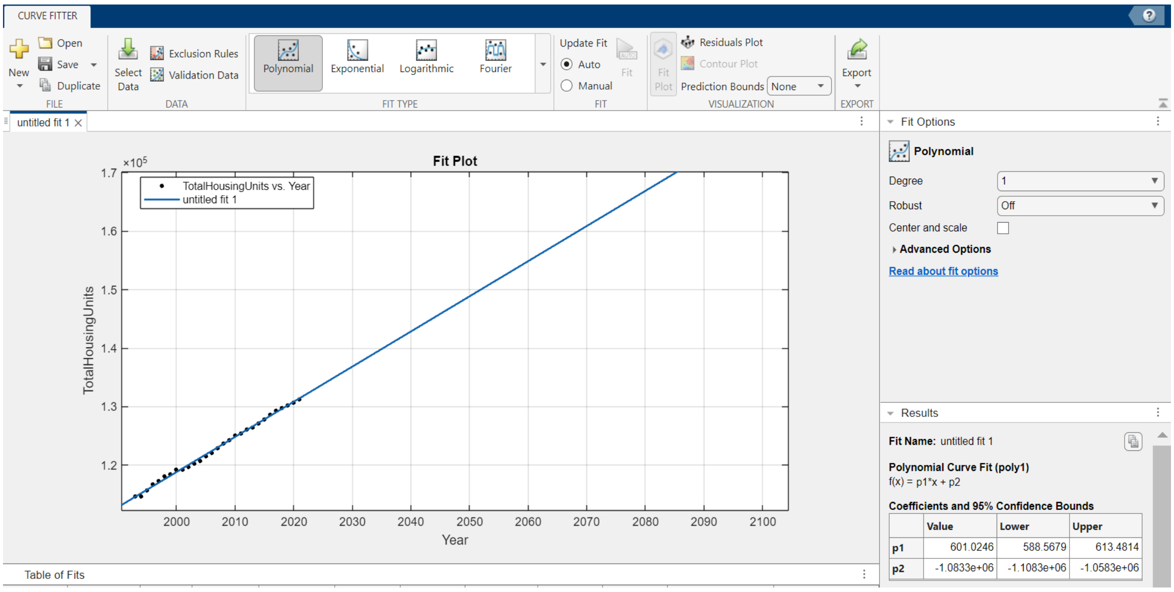
[redacted]

MATLAB

Q1) Manchester:



Q1) Brighton



[redacted]