

# To Buy or Rent a Home as a New Grad

ISyE 516

Group 11

Praharshith Jamalapuram, Jose Perales Sorni, Kaushik Ramakrishnan,  
Sinfeney Teng

## Abstract

Being a new grad looking to work in the Madison area, it is important to decide whether to buy or rent a home. The objective of this decision is to maximize future investment return and maximize happiness. There are several factors that might affect the decision, for example, the housing cost, the flexibility of moving, the quality and number of roommates, the location of home, and future investment return. We used the decision tree as our decision model. To make the final decision, two factors we considered are the degree of happiness and future investment return. After analysing the decision tree, the final decision strategy turned out to be buying a condo in downtown Madison. We also performed a one-way sensitivity analysis to detect the factors that would affect the final decision. And future investment return seemed to be the most affecting factor that might alter the decision.

## Decision Narrative

### ● Decision Context

All the important decisions must be made after a deep analysis. The intention with this project is to put ourselves in the shoes of a recently graduated student working professional who is relocating to Madison, Wisconsin. As this student moves, he must decide whether to buy or rent a home for the future 15 years. This decision is crucial as it impacts their financial stability, lifestyle, and long-term investment potential. Various factors, such as housing costs, location, roommate selections and house type influence this choice. Given that they are moving to a new state, they face uncertainties regarding job stability, real estate trends, and roommate quality, all of which must be considered in making an informed decision.

### ● Objectives

Since the student just started working, their end objective is to maximize future investment returns and maximize happiness. The main objective is **to maximize overall happiness**, which depends on the success of investment, the monthly payment, the number of roommates and the freedom that each alternative reports.

### ● Alternatives

The student takes the number of roommates, home location, and property type into account. Renting a home has the freedom to relocate at any time, but has to face the uncertainty of having a good or bad roommate if they choose to live with others. For renting, there are three alternatives: **renting a home alone, renting with one roommate, and renting with two roommates**. Buying a home has the freedom to decide how many roommates they want to live with. They can decide the location and the home property as well. The buying options are: **buying a condo downtown, buying a house downtown, buying a condo in the outskirts area, and buying a townhouse in the outskirts area**.

### ● Uncertainties and Qualitative Outcomes

One of the main uncertainties is the **quality of the roommate**, meaning it is uncertain if the roommate is good or bad. Here we set the roommate quality of two roommates as both good

roommates or both bad roommates. Though property appreciation rate, mortgage rate, and the rental inflation rate might be fluctuating, we fix these rates at a fixed number for simpler calculation. The qualitative outcomes are rent alone, rent with one or two good roommates, rent with one or two bad roommates, buy a condo downtown, buy a townhouse downtown, buy a condo in the outskirt area, and buy a townhouse in the outskirt area.

## **Datasets**

Rental market trends & average rent in Madison, WI(2025) is used to provide the average rental rate for the renting alternative. It contains the data of either studio, one bedroom, or two bedrooms in the Madison area. We use the data to help evaluate the total housing cost for renting, and to compare the cost of buying a home. The data provides references for constructing the decision tree and sensitivity analysis.

The median sale price of downtown homes are indicated in Redfin(Feb, 2025). We will use the data to compare with the home sale price in outskirt Madison.

As of the buying alternative branch of the analysis, Zillow is used to average buying price across various house type options, such as Townhouse, House & Condo. We used the data to gauge the range and average of housing buying price and any observed fluctuations depending on the neighbourhood or any other factors, such as the house condition & the amount of repairs required.

## **Analysis Methods**

We used a utility function to compute the happiness score of each outcome. We used the utility function because each happiness aspect has different importance. And by giving every aspect its weight, we can compute the happiness score and evaluate each outcome in an objective aspect.

We also used a decision tree because it can easily compare the degree of happiness using the expected value between the seven alternatives. Also it enables us to include some personal factors such as preference of number of roommates and what type of house a person would like to purchase. A decision tree allows us to break down the problem into two smaller problems, “Rent” and “Buy”. With this approach we can clearly define the different outcomes and the reasons that would cause them. Moreover, since we are using two factors in our decision, happiness and cost of living, the decision tree allows us to mix both and analyze the repercussions of each decision/uncertainty, using financial and qualitative factors.

In the sensitivity analysis, we plan to focus on how the different happiness aspects affect happiness according to the weights and the values per option. The happiness aspects and the weight could affect the final result. For example, it won't be the same to give 20% weight to freedom rather than giving a 50%, or giving more weight to the final investment rather than the actual cost. The sensitivity analysis will show how changes in weight percentages affect the final decision. Moreover, in the rent branch of the decision tree, the possibility of having a good or a bad roommate is difficult to predict, so it is interesting to use the sensitivity analysis to know if the final decision is sensitive to this uncertainty and at what scale. On the other hand, in the buy branch we could focus on analyzing the property appreciation rate because it looks like the

changes in the parameter could impact the final decision and it would be interesting to measure it.

## **Decision Model**

To identify the best decision strategy, the criteria we used is a total score called “happiness” which depends on multiple factors listed and explained below. Two of the most important drivers of the total happiness are the “happiness of investment” (calculated in “Table 1”) and the “monthly expense”, which is calculated in the “Table 2”. These two main drivers has the following subdrivers:

- Home price: obtained from different sources included in the references.
- Yearly mortgage costs: calculated with 6.125% mortgage rate. The mortgage would be totally paid in 15 years, and we suppose that the upfront payment is zero due to a bank policy with just newly graduated people.
- Maintenance cost per year: calculated as 1% of the house value.
- Insurance per year: obtained with the help of AI considering the Madison area, the price difference and the type of house.
- Expense in 15 years: for buying, total expense was calculated by summing home price, mortgage, maintenance cost, and insurance. In the renting case, we have considered a 5% annual appreciation in the cost of renting. The initial rent price for living alone is \$1,414; for living with one roommate is \$2,270 divided by 2, and for living with 2 roommates is \$2,604 divided by 3. And the rental inflation rate was 5% per year. All data is supported by the databases included in the references and by AI.
- Monthly expense: since it might be stressful for a new graduate student to pay the high mortgage in the beginning without having a stable job, we take monthly expenses as a factor that might affect happiness. And this aspect is gained from expense in 15 years divided by 180 months. (Table 2.)
- House price after 15 years: for buying, we considered a 5% annual increase rate in the value of the houses according to the same mentioned sources. For renting, since the property does not belong to the individual, the score here would be 0.

The happiness of investment was calculated after computing the total expenses in 15 years and the future house price after 15 years. The option with the highest investment returns has the highest score 10 and the lowest is scored 0. Monthly happiness score is defined as the degree of happiness gained from the monthly expense, which will have a value of 0 happiness for the highest monthly expense and a 10 for the lowest.

Once the future investment returns and the monthly expense have been defined, we looked at the other three main drivers that the total happiness value has:

- Roommates: we assume living alone is the happiest, and the happiness value reduces when the number of roommates increases. It also changes depending on the quality of roommates.
- House type: we assumed that a rented house can't be more than 5 in happiness since we can't design it. For the buying option we assume that downtown has a higher score than outskirts and house is better than the condo.

- Freedom to relocate: there is more freedom to relocate if we choose to rent because it would be easier to end a contract and relocate if needed.

## Decision Results

In our case, we assigned the weight of each happiness aspect in order to compute the total happiness. The total happiness per outcome is calculated as follows:

$$\begin{aligned}
 TOTAL\ HAPPINESS &= 0.1 * happiness(roommates) \\
 &+ 0.15 * happiness(house\ type) \\
 &+ 0.25 * happiness(freedom) \\
 &+ 0.4 * happiness(happiness\ of\ investment) \\
 &+ 0.1 * happiness(expense\ happiness)
 \end{aligned}$$

The happiness score for each aspect is listed in “Table 3” in the appendix. We derived the score of each aspect and each outcome from our group survey. Having the total happiness per outcome we can calculate the expected values of the decision tree (*Graph 1*) to see which decision strategy we should choose according to the assumptions done.

The best decision is to **buy a house downtown** because it would return the highest total happiness value according to the calculation of the main 5 happiness aspects.

## Sensitivity analysis

To assess which variable most strongly influenced our decision, we conducted a one-way sensitivity analysis and visualized the results using a tornado plot (Figure 1). The variables we chose to conduct the one-way sensitivity analysis are: roommates, house type, freedom to relocate, happiness of future investment returns, and happiness of monthly expenses. The plot illustrates how percentage variations in individual variables affect the outcome, with all others held constant.

The base case is set as the best decision strategy from the decision analysis, to buy a house in downtown Madison. From figure 1, we identified Future Investment as the most sensitive variable. It shows the widest range of impact on the outcome, ranging from nearly -60% to 0% deviation from the base case. This suggests that even modest over- or underestimation of future investment returns can substantially alter our decision strategy.

Following that, Freedom and House Type also display notable sensitivity, each shifting the outcome by up to around +40% and -25%, respectively. In contrast, Monthly Expense and Roommates show much smaller variations, indicating they are less influential in changing the decision outcome.

The uncertainty is the quality of roommate. Since the quality of a roommate only has an effect on renting, we set the base case to the best decision strategy if we chose to rent a home, namely rent a home with 2 roommates, with the happiness score as 5.06. Also, we set the bound of roommate from 0 to 6 since this is the happiness range of having two roommates.

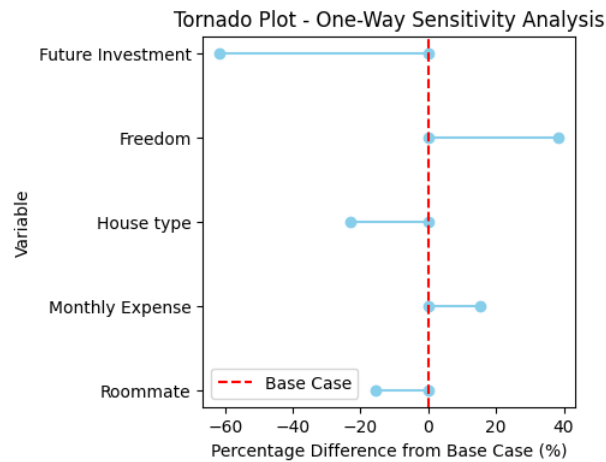


Figure 1. Tornado plot for base case being buying a house in downtown

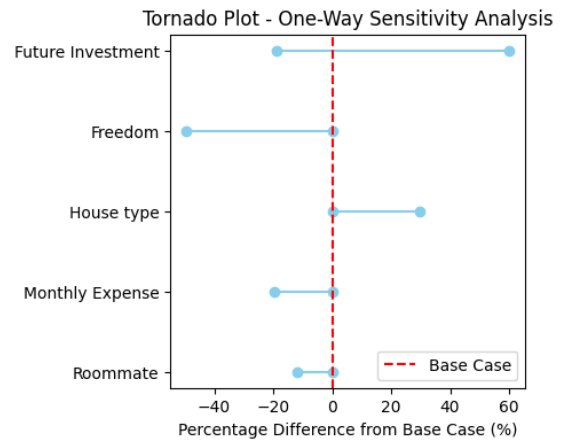


Figure 2. Tornado plot for base case being renting with 2 roommates

Figure 2 is the tornado plot of analyzing the effect of quality of roommate. This aspect changes from -15% to 0% of the base case, and shows not much changes from the first tornado plot, indicating that the quality of roommate does not have much effect on the decision.

Sensitivity analysis revealed that future investment return is the most influential factor, while roommate quality has minimal impact. To reduce uncertainty, we suggest incorporating probabilistic modeling for more robust decision-making.

## Conclusions

This project aimed to determine whether a new graduate should buy or rent a home in Madison, WI, by maximizing both future investment return and happiness. We built a decision tree model incorporating key factors such as home type, roommate situation, freedom to relocate, and financial outcomes. Each alternative was evaluated using a weighted utility function based on group survey data.

Our analysis found that buying a house downtown offers the highest total happiness, primarily due to strong investment returns, despite higher upfront costs. Sensitivity analysis highlighted future investment return as the most impactful factor, while variables like roommate quality had minimal influence.

A key strength of our approach is its combination of financial and personal well-being factors, making it adaptable to similar decisions faced by other young professionals. This framework can help individuals make more informed, holistic housing choices.

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## Appendix

|                     | Home price | Yearly mortgage cost | Maintenance yearly cost | Insurance per year | 15-year Expense | House price after 15 years | Final Investment Returns | Happiness of investment |
|---------------------|------------|----------------------|-------------------------|--------------------|-----------------|----------------------------|--------------------------|-------------------------|
| Rent-live alone     | 0          | 0                    | 0                       | 0                  | \$366,145       | 0                          | -\$366,145               | 0                       |
| Rent-1 roommate     | 0          | 0                    | 0                       | 0                  | \$293,900       | 0                          | -\$293,900               | 1.23                    |
| Rent-2 roommates    | 0          | 0                    | 0                       | 0                  | \$224,762       | 0                          | -\$224,762               | 2.4                     |
| Buy downtown condo  | \$465,000  | \$48,269             | \$4,650                 | \$900              | \$807,292       | \$966,702                  | \$159,409                | 8.92                    |
| Buy downtown house  | \$720,000  | \$74,740             | \$7,200                 | \$3,000            | \$1,274,098     | \$1,496,828                | \$222,730                | 10                      |
| Buy outskirts condo | \$325,000  | \$33,737             | \$3,250                 | \$700              | \$565,301       | \$675,652                  | \$110,351                | 8.09                    |
| Buy outskirts house | \$439,000  | \$45,571             | \$4,390                 | \$2,100            | \$780,908       | \$912,649                  | \$131,741                | 8.45                    |

*Table 1. Investment returns and happiness score of different decision strategies*

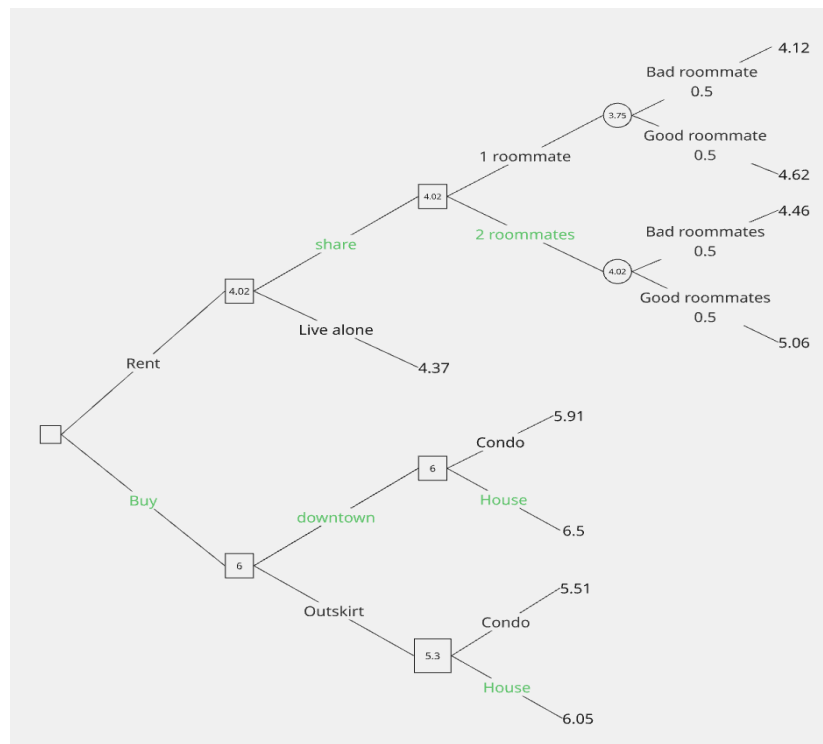
|                     | 15-year Expense | Monthly expense | Happiness of Monthly Expense |
|---------------------|-----------------|-----------------|------------------------------|
| Rent-live alone     | \$366,145.07    | \$2,034.14      | 8.65                         |
| Rent-1 roommate     | \$293,900.04    | \$1,632.78      | 9.34                         |
| Rent-2 roommates    | \$224,762.32    | \$1,248.68      | 10.00                        |
| Buy-downtown condo  | \$807,292.34    | \$4,485         | 4.45                         |
| Buy-downtown house  | \$1,274,097.82  | \$7,078         | 0.00                         |
| Buy-outskirts condo | \$565,301.10    | \$3,141         | 6.75                         |
| Buy-outskirts house | \$780,908.25    | \$4,338         | 4.70                         |

*Table 2. Expenses and happiness of monthly expense of every decision strategy*



|                          | Roommate<br>(0.1) | House type<br>(0.15) | Freedom<br>(0.25) | Happiness of<br>investment<br>(0.4) | Happiness of<br>monthly expense<br>(0.1) | TOTAL<br>HAPPINESS |
|--------------------------|-------------------|----------------------|-------------------|-------------------------------------|--|--------------------|
| Rent-live alone          | 10                | 0                    | 10                | 0                                   | 8.65                                     | 4.37               |
| Rent-1 good<br>roommate  | 7                 | 0                    | 10                | 1.23                                | 9.34                                     | 4.62               |
| Rent-2 good<br>roommates | 6                 | 0                    | 10                | 2.40                                | 10.00                                    | 5.06               |
| Rent-1 bad<br>roommate   | 2                 | 0                    | 10                | 1.23                                | 9.34                                     | 4.12               |
| Rent-2 bad<br>roommates  | 0                 | 0                    | 10                | 2.40                                | 10.00                                    | 4.46               |
| Buy-downtown<br>condo    | 10                | 6                    | 0                 | 8.92                                | 4.45                                     | 5.91               |
| Buy-downtown<br>house    | 10                | 10                   | 0                 | 10.00                               | 0.00                                     | 6.5                |
| Buy-outskirt<br>condo    | 10                | 4                    | 0                 | 8.09                                | 6.75                                     | 5.51               |
| Buy-outskirt<br>house    | 10                | 8                    | 0                 | 8.45                                | 4.70                                     | 6.05               |

Table 3. Happiness score of all possible outcomes



Graph 1. Decision Tree