AccuConsulting

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Executive Summary:

Everyone dreams of having a place they can call home. No matter how big or how small we look for places where we can create memories along with our families. However, this process can often be very stressful for people who aren't familiar with how the housing market works. Here at AccuConsulting, we seek to facilitate this process by providing people with a clear and simple explanation of what it means to have a mortgage and how much they can afford. Through this, we seek to attract more people to invest in a home and thus you, the bank, can profit from this process.

In this report we sought to create plots and charts people can easily understand in order to make them more comfortable with the idea of getting a mortgage for a house. These plots were created using the R code and the average interest rate on a mortgage in San Diego. We analyzed 4 different types of loans that a customer would be mostly interested in. These are the 10-year, 15-year, 20-year, and 30-year loans. Along with their respective interest rates of 5.49%, 5.759%, 5.997% and 6.448%.

After our analysis, we concluded that being able to convince people to go with a longer loan period will increase profits for your bank due to the increased interest they would pay. We were also able to come up with plots we believe will convince people a 30-year loan will benefit them too.

Introduction:

The task at hand is to motivate people into at the very least taking out a mortgage for a house. Oftentimes people shy away from things they don't know much about. Here we want to work on presenting mortgage loans in the simplest of terms so people are willing to invest in a house since they will no longer be afraid of the process.

In our analysis, we took the average interest rate of San Diego houses provided by NerdWallet, https://www.nerdwallet.com/mortgages/mortgage-rates/california/san-diego. We also utilize the average cost of a house in San Diego provided by Zillow, https://www.zillow.com/home-values/54296/san-diego-ca/. This data allows us to represent to our customers what a mortgage loan would look like depending on what type of loans they choose in San Diego. The data also allows us to represent to our customers the effect of different interest rates on their monthly payment and their total payment to the loan at the end of 30 years.

We also extracted the average annual value growth of a house in San Diego. Provided by https://www.noradarealestate.com/blog/san-diego-real-estate-market/#:~:text=NeighborhoodScout.com's%20data%20also%20shows,slightly%20above%20the%20national%20average. With this data, we sought to show customers how an investment in a home can pay off despite the increased interest paid on a house in the long run. Thus encouraging people to take longer-term loans and thus increasing the profits of the bank.

The first thing we believe is most important in this process is presenting the multiple variables that go into a mortgage. Here at AccuConstulting, we decided the best method of approach is to derive a mortgage formula for customers to understand.

In order to derive this formula we will attempt to imitate how a monthly payment would bring down the total principal borrowed to the point where it is all eventually paid off.

We also decided to show customers the value appreciation a house has over a large span of time in order to justify the larger interest that is paid when having a longer loan.

Data and Methods:

In order to tackle this problem we decided to look at two major formulas that will allow us to make proper analysis. To describe how a mortgage works we decided to derive a mortgage formula. We begin by labeling the total amount of principal borrowed as *P*, like stated above *r* is the monthly interest, and *x* is the monthly payment. The first 3 months would look something like the following:

$$P_1 = P + Pr - x = P(1 - r) - x$$

$$P_2 = P_1(1 + r) - x = P(1 + r)^2 - (1 + r)x - x$$

$$P_3 = P_2(1 + r) - x = P(1 + r)^3 - (1 + r)^2 x - (1 + r)x - x$$

At this point we can see the pattern and we can generalize the formula up to the *k*th month.

$$P_k = P(1 + r)^k - (1 + r)^{k-1} x - \ldots - (1 + r)^2 x - (1 + r)x - x$$

$$P_k = P(1 + r)^k - x\frac{1-(1+r)^k}{r}$$

From this point we can utilize the well known geometric series to simplify. We can also set P_k it equal to zero since we assume that this is the last month and the debt is completely paid off. Thus leaving us with:

$$0 \ = \ P(1 + r)^n + x\frac{1-(1+r)^n}{r}$$

$$x = \frac{P(1+r)^n r}{(1+r)^n - 1}$$

With this formula we can now calculate the monthly payments of a mortgage depending on the interest rate, the value of the house and number of months we have to pay. It is important to make the distinction that r is a monthly interest rate. Normally banks will give annual interest rates therefore to convert we simply use the following formula:

$$r \ = \ \frac{Annual\ Interest\ Rate}{12}$$

Lastly, n represents the longevity of the loan. Once again it is important to make the distinction that the formula shows the monthly payment therefore n must have months as the unit.

There is one more formula we derived in order to perform an analysis of how profitable it is to buy a house despite the interest paid. Let V equal the value of the house after at *nth* year and let P equal the original value of the house. We use the appreciation rate of 8.45% from our sources:

$$V_1 = P(1.0845)$$

$$V_2 = V_1(1.0845) = P(1.0845)^2$$

$$V_n = P(1.0845)^n$$

With this formula we are able to determine how profitable it is to get a 30-year mortgage loan for a house.

Solutions and Results:

As stated before we utilized the Mortgage formula presented below:

$$MP = \frac{P \cdot r(1+r)^n}{(1+r)^n - 1}$$

In order to demonstrate this formula we will utilise the data gathered from our sources stated in the section above.

Looking at a 30-year loan we can find that the annual interest rate is 6.448%. Therefore the monthly interest rate is 0.5373%. In order to use this percentage in our formula we must divide by 100. Since we took out a loan of 30 years our loan period is 36 months. Lastly, we need to know the cost of our house, the average cost of a house in San Diego is about $950,415 according to Zillow. Plugging all of these variables in:

$$MP = \frac{950414 \cdot .005373(1+.005373)^{36}}{(1+.005373)^{36} - 1}$$

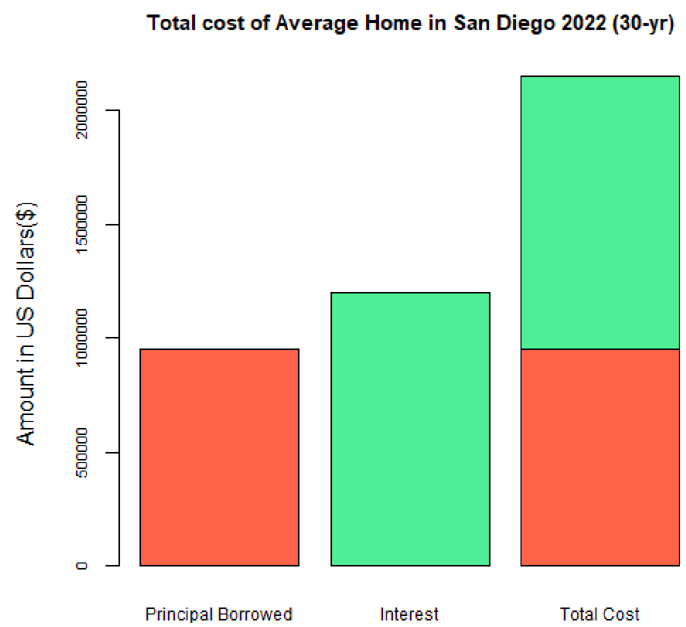
$$MP = \$5974.80$$

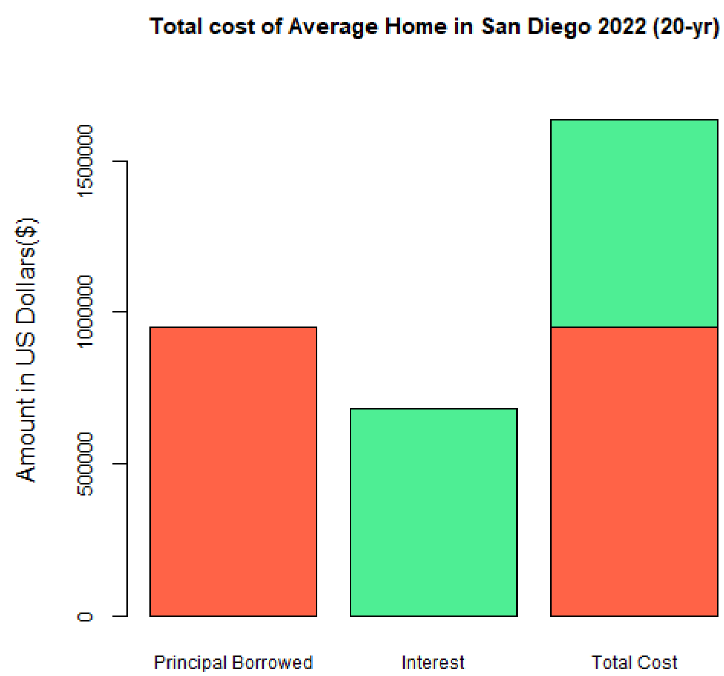
We can now see that our monthly payment for this 30-year loan would be $5,974.80. This same process was used for the 10-year, 15-year, and 20-year loans with their respective interests.

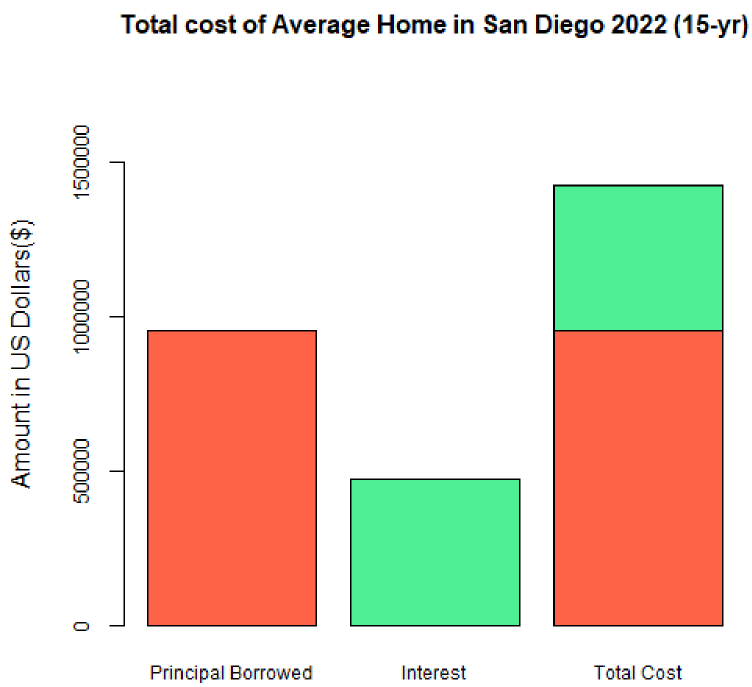
The next formula we utilized was one where we can find the total amount of interest paid for each individual loan type. We simply multiplied the monthly payment by the total number of months and subtracted the original principal borrowed:

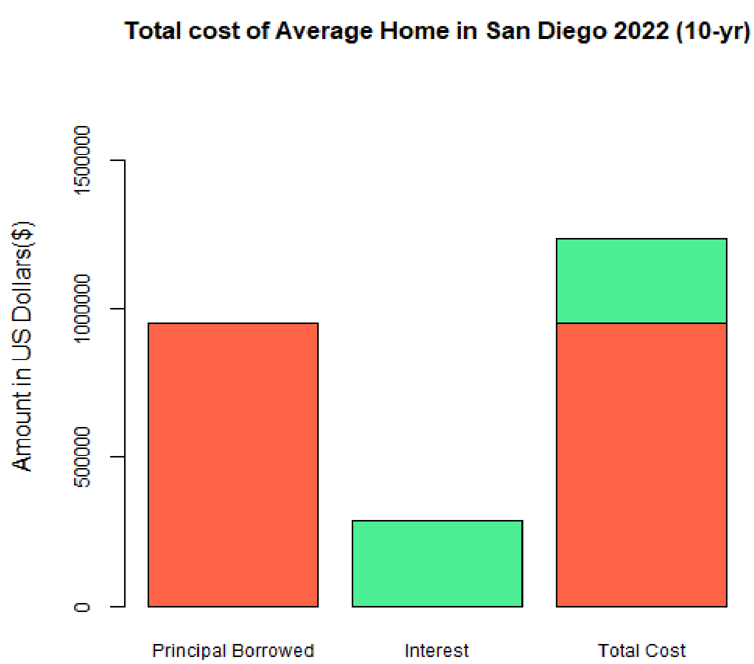
$$Total\ Interest = (MP * n) - P$$

Both these formulas were used to create the following plots:

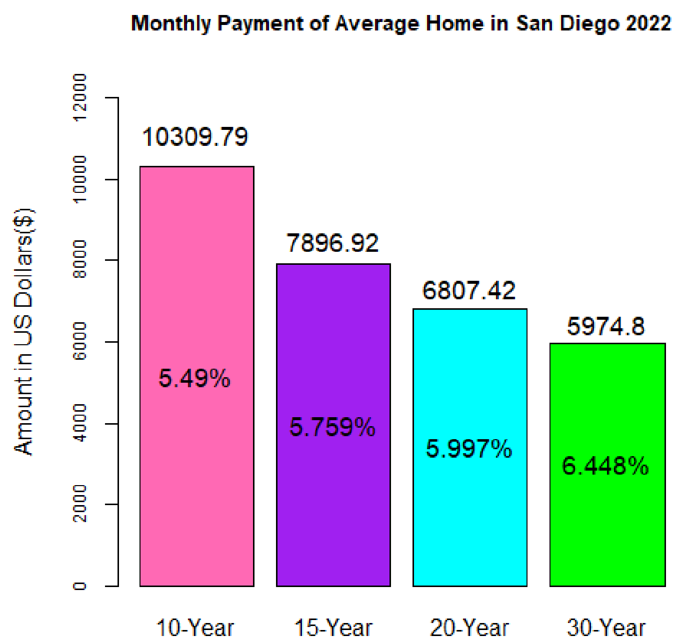





Total cost of Average Home in San Diego 2022 (15-yr)
Amount in US Dollars($)
0
500000
1000000
1500000
Principal Borrowed
Interest
Total Cost

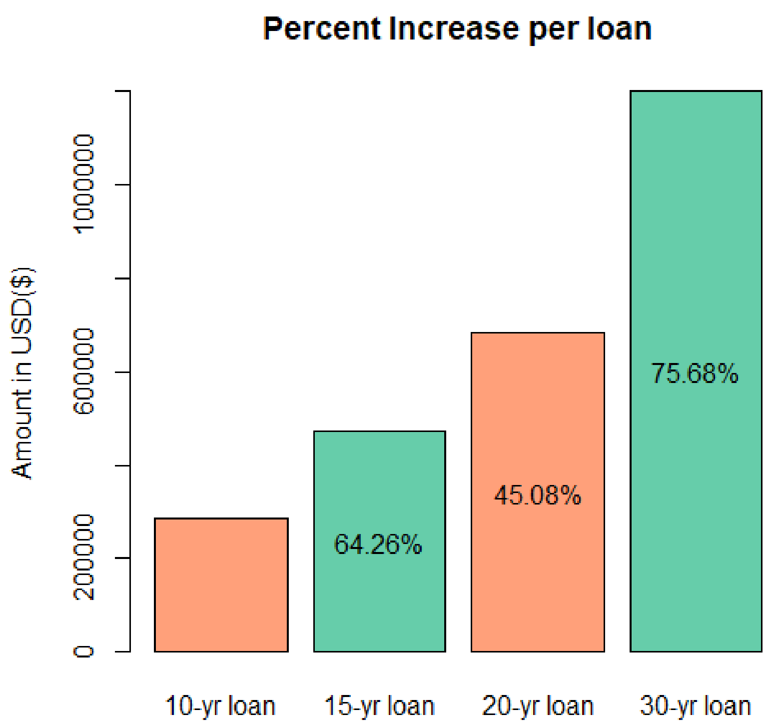

Total cost of Average Home in San Diego 2022 (10-yr)
Amount in US Dollars($)
0
500000
1000000
1500000
Principal Borrowed
Interest
Total Cost

As shown in these plots the total payment of a mortgage goes down as the loan term does as well. These plots are pretty self-explanatory, the orange area shows the total amount of principal borrowed and the green area shows the interest. When combined we get the total payment to the bank. Although these plots alone might encourage a consumer to get a smaller term on the loan it doesn't show how affordable it is on a monthly basis. Therefore, we created the following plot to demonstrate how affordable these different loans are.



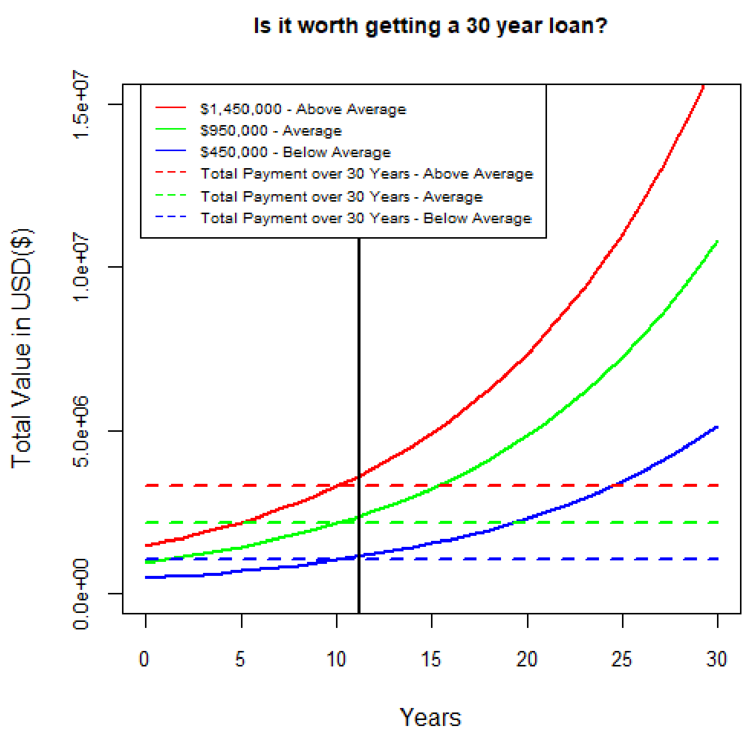
In this plot we aimed to show how the different loan terms compare in terms of their monthly payment, once again calculated using the monthly payment formula shown earlier. Here we can clearly see that although we are paying more interest a longer term loan can provide people a more affordable monthly payment. It is clear to see that taking a longer-term loan will enable us to buy a house with a higher value since our monthly payments are further stretched out. Thus despite paying more interest, it might be worth getting longer-term loans.

In order to further contextualize this idea we generated another bar plot showcasing the different total value jumps in loan terms. That way customers can have an idea of which loan term they would rather take.



This plot demonstrates the total amount of interest that is paid on a loan depending on its length. It appears to be that if someone is considering jumping from a 20-year loan to a 30-year loan there is a 75% increase in the amount of interest that is paid. However, in the plot before this, we can see that the difference between the monthly payment of the 20-year loan and the 30-year loan is about $832.62. Thus it is up to the consumer to determine whether this jump is worth it.

In order to provide more concrete evidence that taking a longer-term loan is worth it for both parties, i.e. the consumer and the bank. We decided to calculate the value of the average San Diego home in 30 years. Using our sources we found that the average house in San Diego appreciated in value about 8.45% every year. The following plot was created using the appreciation formula we derived previously.



In the plot above we can see the value of the house grows exponentially assuming houses continue to appreciate at a constant percentage. The plot above shows how around the 11-year mark the value of the house will surpass that of the total payment for the loan, this is represented by the black vertical line. This plot allows us to show that 30-year loans give the customer a more affordable monthly payment and in the long run a pretty substantial profit margin. Thus, allowing both the bank and the customer to have increased profits.

Conclusion:

These are the analyses we conducted here at AccuConsulting. We believe that with the plots we have generated we are able to convey clearly that obtaining a longer loan term will benefit the consumer. Ultimately, the best way for the bank to increase profits is to be able to obtain more interest on a house and a sure method of this will be to have consumers take out 30-year loans.

We were able to show consumers that taking out a 30-year loan will enable them to have a better monthly payment on a house that might otherwise be out of their budget. We were also able to show that taking out this 30-year loan pays off in the long run since houses continue to appreciate on a yearly basis. We were able to show that around 11 years after the mortgage was taken out the house value will be higher than the total amount paid to the loan. Thus there is more profit to be made despite having to pay a higher interest rate.

Although all of the above is a positive we should point out there are a few cons to our methods. The biggest one is that interest rates are constantly changing, as well as the fact that houses don't increase in value at a constant percentage. Thus a house's value might not surpass the total paid for a mortgage loan within exactly 11 years as we predicted. However, it does serve as a reference to the fact that if things continue how they have a long-term loan will produce profits.

References:

1. https://www.noradarealestate.com/blog/san-diego-real-estate-market/#:~:text=NeighborhoodScout.com's%20data%20also%20shows,slightly%20above%20the%20national%20average.
2. https://www.nerdwallet.com/mortgages/mortgage-rates/california/san-diego
3. https://www.zillow.com/home-values/54296/san-diego-ca/

Code for Plots:

```
### 30 Years ###
P = 950415
r = .06448/12
n = 360

Mort30 = P*((1+r)^n)*r/((1 + r)^n -1)
Mort30
M30tot = Mort30*n
M30int = Mort30*n - P
M30Bar = matrix(c(P,0,0,M30int,P,M30int),2,3, byrow = F)

M30 = barplot(M30Bar,main = "Total cost of Average Home in San Diego 2022 (30-yr)",
        col = c("tomato1","seagreen2"),
        names.arg = c("Principal Borrowed","Interest","Total Cost"),
        cex.axis = .7, cex.names = .75, cex.main = .95,
        ylab = "Amount in US Dollars($)")

### 20 Years ###
P = 950415
r = .05997/12
n = 240
```

```
Mort20 = P*((1+r)^n)*r/((1 + r)^n -1)
Mort20
M20tot = Mort20*n
M20int = Mort20*n - P
M20Bar = matrix(c(P,0,0,M20int,P,M20int),2,3, byrow = F)

M20 = barplot(M20Bar,main = "Total cost of Average Home in San Diego 2022
(20-yr)",
        col = c("tomato1","seagreen2"),
        names.arg = c("Principal Borrowed","Interest","Total Cost"),
        cex.axis = .8, cex.names = .75, cex.main = .95,
        ylab = "Amount in US Dollars($)", ylim = c(0,1750000))

### 15 Years ###

P = 950415
r = .05759/12
n = 180

Mort15 = P*((1+r)^n)*r/((1 + r)^n -1)
Mort15
M15tot = Mort15*n
M15int = Mort15*n - P
M15Bar = matrix(c(P,0,0,M15int,P,M15int),2,3, byrow = F)

M15 = barplot(M15Bar,main = "Total cost of Average Home in San Diego 2022
(15-yr)",
        col = c("tomato1","seagreen2"),
        names.arg = c("Principal Borrowed","Interest","Total Cost"),
        cex.axis = .8, cex.names = .75, cex.main = 1,
        ylab = "Amount in US Dollars($)", ylim = c(0,1750000))

### 10 Years ###

P = 950415
r = .0549/12
n = 120
```

```
Mort10 = P*((1+r)^n)*r/((1 + r)^n -1)
Mort10

M10tot = Mort10*n
M10int = Mort10*n - P
M10Bar = matrix(c(P,0,0,M10int,P,M10int),2,3, byrow = F)

M10 = barplot(M10Bar,main = "Total cost of Average Home in San Diego 2022
(10-yr)",
        col = c("tomato1","seagreen2"),
        names.arg = c("Principal Borrowed","Interest","Total Cost"),
        cex.axis = .8, cex.names = .75, cex.main = 1,
        ylab = "Amount in US Dollars($)", ylim = c(0,1750000))

### Monthly Payment Comparison ###

MonthPayVal = c(Mort10,Mort15,Mort20,Mort30)
Interest = c(5.49,5.759,5.997,6.448)
MonthPay = barplot(MonthPayVal, main ="Monthly Payment of Average
Home in San Diego 2022",
           names.arg = c("10-Year", "15-Year","20-Year","30-Year"),
           col = c("hot pink","purple","cyan","green"),
           cex.axis = .75,cex.names = 1, cex.main = .95,
           ylab = "Amount in US Dollars($)", ylim = c(0,12500))

text(MonthPay, MonthPayVal/.93, labels = round(MonthPayVal, digits = 2), cex =
1.1)
text(MonthPay, MonthPayVal/2, labels = c("5.49%","5.759%","5.997%","6.448%"),
cex =1.1)


### Total Interest Amount ###

interests = c(M10int,M15int,M20int,M30int)

intinc = c(abs(M10int - M15int)/M10int,abs(M15int - M20int)/M15int,
      abs(M20int - M30int)/M20int)
intinc
```

```
InterestIncrease = barplot(interests, col =
c("lightsalmon","mediumaquamarine"),
                       main = "Percent Increase per loan",
                       names.arg = c("10-yr loan","15-yr loan",
                                   "20-yr loan","30-yr loan"),
                       ylab = "Amount in USD($)")
text(InterestIncrease,interests/2,labels = c("","64.26%","45.08%","75.68%"))

### Potential profits ###

GrowthForm = function(P,n){P*(1.0845)^n}
AboveAvg = P+500000
BelowAvg = P-500000

plot(seq(0,30,by=1),GrowthForm(AboveAvg,seq(0,30,by=1)),type = 'l', col = 'red',
lwd = 2,ylim = c(0,15000000),
    main = "Is it worth getting a 30 year loan?", ylab = "Total Value in USD($)"
    ,xlab = "Years",cex.axis = .8, cex.main = .9, xlim = c(0,30))

lines(seq(0,30,by=1),GrowthForm(P,seq(0,30,by=1)),col = "green",lwd = 2)
lines(seq(0,30,by=1),GrowthForm(BelowAvg,seq(0,30,by=1)), col = "blue", lwd =
2)
lines(years30,M30tot + years30*0, col = 'green', lty = 2, lwd = 2)
lines(years30,M30Atot + years30*0, col = 'red', lty = 2, lwd = 2)
lines(years30,M30Btot + years30*0, col = 'blue', lty = 2, lwd = 2)
lines(11.25 + years30*0,seq(-10000000,16000000,length.out = 31), lwd = 2)
legend(-.250,15595000,c("$1,450,000 - Above Average","$950,000 -
Average","$450,000 - Below Average",
                    "Total Payment over 30 Years - Above Average", "Total Payment
over 30 Years - Average",
                    "Total Payment over 30 Years - Below Average"),lty = c(1,1,1,2,2,2),
      col = c("red","green","blue","red","green", "blue"),cex = .6)
```