AffordIt Algorithms Document

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1 Introduction

A couple of years ago, I sold a home in San Luis Obispo to relocate to San Jose. Since then, I've missed the pleasure – and tax benefits – of owning a home. So I started shopping for another house. But how much can I afford?

With my Bachelor's of Science in Math and Physics in hand, I derived a simple equation to answer this question. It's simple, but it's complex enough to make hand calculations a pain. So I created a little calculator.

It's distributed with the intent that everybody should make this calculation to avoid getting in over their head with a mortgage.

AffordIt is written in Java using Swing and the latest Java Run Time Environment.

2 The Basic Calculation

To purchase a home you need a down payment and, usually, a loan called a mortgage[1]. You also need to get property insurance and pay property taxes. If the loan is non-conforming[2], then lenders will require you to get mortgage insurance in addition to property insurance. If you want to live in a home or a condo in a planned development you will also need to pay a monthly Home Owner's Association (HOA) fee. In some cases, the HOA dues include property insurance. A typical monthly payment covers principal, interest, property taxes, and insurance (PITI).

Lenders only allow debtors to spend a particular fraction of their gross income, usually about 35%, on housing or other debt. Lenders call this the debtor's "debt ratio."

You need to take all of these variables into consideration while computing how much home you can afford. Table 1 summarizes these variables.

Breaking down the expenses: the allowed debt (gross income times debt ratio) has to cover a years worth of monthly mortgage payments (principal and

[1] Freddie Mac provides some excellent advice, and calculators for prospective home buyers. Of course, AffordIt is more thorough, accounting for HOA, taxes, and mortgage insurance.

[2] A non-conforming loan is a loan that fails to meet bank criteria for funding. These loans were very, very common in the housing bubble.

Let's take a look at what we're working with:

	Assets
I	Gross Annual Income
ρ	Debt Ratio
D	Down Payment
P	Mortgage Principal
A	Available Income (ρI)
X	Market Moxie *(see below)*
	Liabilities
H	Home Price
i	Mortgage Annual Interest Rate (Percentage)
m	Annualized Mortgage Payment
s	Annual Insurance Premium
q	Mortgage Insurance Rate (Percent of Principal)
qP	Annual Mortgage Insurance Premium
d	Annualized HOA Dues
t	Property Tax Rate (Percent of Home Price)
tH	Annual Property Taxes
p	Annualized Other Debt Payment

Table 1: The pertinent variables.

interest), property taxes, insurance dues, HOA dues, garden gnomes, mortgage insurance dues, and any additional debt payments. In symbols:

$$\rho I = m + tH + s + d + p + qP \tag{1}$$

Simplify the computation by using a year's worth of payments at a time.

Uncle Sam wants you to own a home. To help with this, the government made mortgage interest and property tax payments "income deductions."

In other words, mortgage interest and property taxes get paid out of gross income. Whereas insurance payments, HOA dues, and any other debt payments are paid after taxes have been deducted from your income.

If available income is measured pre-tax, then we can scale these post-tax expenses up into pre-tax dollars to make a yet more conservative estimate.

Let's say the tax rate is about 40% overall. This means that post-tax dollars are worth about 60% of pre-tax dollars.

So a fraction of gross income has to cover the post-tax costs, which now looks like

$$\rho I = m + tH + (s + d + p + qP)/0.6 \tag{2}$$

This makes for a very conservative estimate (it leads to a more frugal home), but gives a better idea of what bills are really affordable by the end of the year.

But that's only half of the answer. To get the other half, we start with the price of the house as the sum of the mortgage principal and any down[3] payment:

$$H = P + D \tag{3}$$

A year's worth of payments[4] on a principal with a 30-year fixed[5] annual interest rate is:

$$m = Pi\left(\frac{((i/12)+1)^{360}}{((i/12)+1)^{360}-1}\right) \tag{4}$$

Substituting equations (3) and (4) into equation (2) gives:

$$\rho I = Pi\left(\frac{((i/12)+1)^{360}}{((i/12)+1)^{360}-1}\right) + t(D+P) + (s+d+p+qP)/0.6 \tag{5}$$

Rearranging equation (5) gives the principal (P) that this debt ratio can afford to carry with all the payments included:

$$P = \frac{\rho I - tD - (s+d+p)/0.6}{t + (q/0.6) + i\left(\frac{((i/12)+1)^{360}}{((i/12)+1)^{360}-1}\right)} \tag{6}$$

Finally, substituting equation (6) back into equation (3) gives the maximum affordable price a person can pay for a home:

$$H = \frac{\rho I - tD - (s+d+p)/0.6}{t + (q/0.6) + i\left(\frac{((i/12)+1)^{360}}{((i/12)+1)^{360}-1}\right)} + D \tag{7}$$

Let's introduce two new variables to make this a little more palatable. One will represent annual available income and is the numerator of equation (6):

$$A = \rho I - tD - (s+d+p)/0.6 \tag{8}$$

The rest of equation (6) represents the amount of principal that each dollar of available income can purchase. For kicks, let's call this x-factor "Moxie":

$$X = \frac{1}{t + (q/0.6) + i\left(\frac{((i/12)+1)^{360}}{((i/12)+1)^{360}-1}\right)} \tag{9}$$

Annual available income is measured in dollars per year. To get final value of dollars for the price of a house, Moxie must be measured in years. Maybe time really is money...

Moxie will prove useful in the hunt for a home. Putting it all together gives a simplified equation for the maximum price someone can afford to pay for a home:

$$H = AX + D \tag{10}$$

[3] Loan and escrow fees are usually under 1% of the purchase price of the home, so they're ignored here. Otherwise, they'd subtract out of the down payment.

[4] Pegg, Ed Jr. "Mortgage." From MathWorld – A Wolfram Web Resource, created by Eric W. Weisstein. http://mathworld.wolfram.com/Mortgage.html

[5] There are other payment plans. This one is common and allows for a simple limit on the maximum affordable price for a home.

3 Using Your Moxie

Knowing the amount of debt a dollar can buy you can be very, very useful when shopping for a home. Let's say you make $\$100,000$ a year, have $\$150,000$ for down payment, and secured a mortgage rate of 6.25%. In this case, your Moxie is about 11.5 years.

In California, property taxes are a percentage of the selling price of the home, typically 1.3%. Fire and earthquake insurance on a home is about $1000 a year. If your bank allows you a 35% debt ratio, you can afford a $\$511,201$ home.

3.1 Private Mortgage Insurance

Of course, that was a very idealized example. Most people don't have $\$150,000$ laying around for a down payment on a house.

If you have less than 20% of the price of the home available for a down payment, then you have to get mortgage insurance. Mortgage insurance is usually between 1.5% and 6.0% of the principal[6] annually.

As shown in Equation (9), mortgage insurance reduces Moxie. For example, if you only have $\$50,000$ for a down payment, and you can find a low mortgage insurance rate of 1.5%, your Moxieis reduced to 8.94 years and you can only afford a $\$342,112$ house.

Needing mortgage insurance means you've incurred a $\$69,089$ penalty to the maximum amount you can afford to pay for a house. If you have bad credit, then the mortgage insurance rate can get up to 6.0%, dropping Moxie down to 5.35 years and the maximum home price down to $\$224,883$.

Times have have really changed since the housing bubble burst.

3.2 Home Owners Associations

In the San Francisco Bay Area, there are no single family homes that cheap (that you might want to actually occupy).

There are, however, a variety of condominiums within this price range. All condos require HOA dues.

With some algebra, you can find out what HOA dues add to the price of a home:

$$H_{equiv} = H_{condo} + dX \tag{11}$$

HOA dues take away from annual available income. Effectively, they add to the cost of the home. In this way, we capitalize HOA dues into a "house equivalent price."

Let's say there's a condominium available for $\$325,000$ with HOA dues of $350 a month ($\$4,200$ annually). Using the same rates that produced a Moxie of about 8.94 years, the "house equivalent price" is $\$362,548$ - too expensive.

[6] According to the Wikipedia article on Mortgage Insurance.

Here's the numbers for a typical home buyer:

$85,000.00	Gross Annual Income
35%	Debt Ratio
$2479.17	Allowed Monthly Payments
($1455.48)	Monthly Principal & Interest Payment
($310.26)	Monthly Property Taxes
($83.33)	Monthly Insurance Payment
($417.65)	Monthly Mortgage Insurance Payment
($2,266.95)	Total Monthly Payments
$51,000.00	Net Annual Income (after taxes)
$4,250.00	Net Monthly Income (after taxes)
$1,983.05	Money Left Over For Other Stuff

Table 2: The final budget.

Similarly, if you're paying for a car at $350 a month and owe less than $37,584, you should pay off the automotive debt with mortgage debt. Remove that car payment, and you can afford to borrow the additional principal.

4 The Final Budget

With all this in mind, let's take a look at what the monthly budget looks like for a buyer making $85,000 and is lucky enough to have $50,000 for a down payment.

According to the equations, this lucky buyer can afford to pay $286,386 for house, but will need mortgage insurance in order to get the loan.

Table 2 itemizes a typical budget. By scaling the insurance payments up into pre-tax dollars before making the estimate, the bills come in under the 35% debt ratio.

5 Summary

I hope this tool is as useful to you as it has been for me. It's been fun to learn Java and provide this tool as a free application.