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Financing a privately owned home: A time oriented risk analysis of combined saving and financing

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Abstract

Financing a privately owned home is often the major financial goal a private household pursues. Typically, the process consists of a savings period followed by the debt amortization. We propose a six variable model to analyze the nature of the process' interest rate risk, which depends materially on the amount of equity used and the loan terms, in particular fixed interest periods. Historical simulations reveal risk profiles and sensitivities of different strategies. Our study distinguishes from related work by focusing on the time span needed to reach the goal. This realistically reflects the situation of households with income restrictions. Thus, we contribute to a broader and more reasonable understanding of financial risk.

Introduction

Financing a privately owned house is a dominate finance activity of middle-class home owners, Campbell (2006). This paper focuses on the total duration of the combined savings and financing process from the first saving to the last debt service payment. Thereby, it is similar the study of housing savings plans (HSP), Plaut & Plaut (2004). However, in a HSP, savings and borrowing rates are typically fixed from the beginning and below market rates. We consider interest rate risk and define it in a time oriented perspective. Risk means that the process may be "longer than desired". This is in contrast to the usual perspective focusing on values being "less than desired". Previous research indicates that in a time oriented risk perspective, which realistically describes many financial decision problems, risk perception and risk behavior may change (Burkhardt (2007); Bouzaima & Burkhardt (2007)). Hence, a separate treatment is justified.

A six variable model of housing finance as a combined saving and financing process

Model specification

The model considers a combined savings and financing process to acquire a private home. The current price of the home is X at any time. Due to inflation and other market factors this price may vary over time. However, in this paper we ignore inflation and other price effects and therefore do not use a time index. While ignorance of general inflation may reflect current developed markets rather well, over longer time periods the assumption is highly restrictive. This holds even more for stable house prices, especially as there is dependence between house prices and interest rates. Hence, our model is a first step towards exploring the time perspective, which concentrates on interest rate risk but does not give the full picture yet.

In the beginning of the process the consumer starts without any initial capital. She receives a regular income, which covers all living expenses including housing. We assume that she spends a certain fraction of the total income on housing be it as a renter or as an owner. Therefore, in each time period t, which are months throughout the paper, she pays an income dependent amount A. The process consists of two phases. During the initial savings period the consumer accumulates the necessary equity. She does not own a home yet and therefore has to pay a rent R. Only the remaining amount $A - R$ can be put aside. To avoid differences in utility we assume that the rented home offers identical living standard as the aspired house. The home purchase is triggered by reaching a certain amount of equity E or an equity ratio $q = E/X$, respectively. The accumulated capital is used, the missing amount financed by an annuity loan. Henceforward, the payments A must cover house maintenance M and debt service. Maintenance costs are assumed to be high enough to keep the property at a constant quality level. Therefore, after full debt repayment the consumer owns a debt free home in a condition as good as new. The assumption that consumers put reconstruction monies aside in lieu of consumption might not fully reflect actual behavior but is crucial to ensure comparability of different strategies. Otherwise, degradation of house value should be included. Naturally, the process duration depends on the relation of payments A and costs (rent R, maintenance M) to the house price X. We denote the relative levels by $A/X = a$, $R/X = r$ and $M/X = m$. The relation r is also referred to a rental yield as often studied in housing finance. A consumer with a low level of income and therefore low relative payments faces a tight financing situation resulting in long process times.

For a given situation, i.e. a combination of X, A, R and M, the process duration crucially depends on interest rates. During the savings period the consumer earns a savings rate s on accumulated capital. For the annuity loan a credit rate c applies. Obviously, a high savings rate and a low credit rate are advantageous. In the following we will study the impact of interest rate risk on the process duration. An important decision variable influencing this risk is the equity ratio q, which we also refer to as financing strategy. A large q requires a long savings time followed by a short financing period; a low q has the opposite effect.

Process duration in the base case example

For fixed interest rates the durations of the savings and the financing period can be calculated analytically. In the following we provide the formulas and evaluate for our base case example. This helps clarifying the model characteristics. We assume a house price of $X = 250{,}000$ and monthly amounts $A = 2{,}000$ available for housing. Rent and maintenance costs are assumed to be $R = 1{,}500$ and $M = 500$, respectively. Interest rates are set as $s = 4\%$ and $c = 6\%$ p.a. Further, we assume an equity ratio of $q = 30\%$.

During the savings period the consumer is able to set aside an amount of A-R each month. In our example this is 2,000 – 1,500 = 500. The accumulated capital S_t is found as the future value of an annuity, Berk & deMarzo (2013). The house purchase is triggered by reaching the required equity, which is 30% ·250,000 = 75,000. Solving the according inequality results in

$$t \geq \frac{\ln\left(\frac{qXs}{A-R}+1\right)}{\ln(1+s)} - 1$$

Evaluation for our example parameters shows approximately $t = 120.5$ months or a bit more than 10 years. The accumulated capital after the savings period is 75,000. Therefore, a loan of 175,000 is required. The debt service payments are A-M = 2,000-500 = 1,500 per month. Calculating the time l when the remaining debt equals zero results in

$$l = \frac{\ln\left(\frac{A-M}{A-M-(1-q)Xc}\right)}{\ln(1+c)}$$

Evaluation for our example parameters shows $l = 175.53$ months or approximately 14.6 years. The total process duration is the sum of savings and financing period, i.e. 296 months or 24.7 years.

Choice of the equity ratio

The impact of interest rate levels on the combined savings and financing process is twofold. High interest rates support saving but make lending more expensive. Low interest rates, in contrast, hinder saving but allow cheap lending. Accordingly, the best financing strategy with respect to the equity ratio should depend on the rate level. We explore the combined effect by considering parallel shifts of interest rates. Figure 1 shows the impact of parallel interest rate shifts on total process time. The savings rate s is varied from 1% to 6%, the credit rate c from 4% to 9% with a constant spread of 3%. The other model parameters are set according to the base case. As expected, the curves are rising in the equity ratio for low rate levels and falling for high rate levels. In a low interest rate environment it is better not to save much but to immediately rely on credit. Initial savings only make sense if rates are high and high-credit strategies become unaffordable. This case is clearly visible in the curves becoming very steep at the left hand side for high rates. The most interesting pattern in the figure is the nearly interest rate insensitive position of medium strategies with equity ratios around 30%. At this level the opposite interest effects cancel out. This suggests that initial saving might increase total process time but effectively reduces interest rate risk.

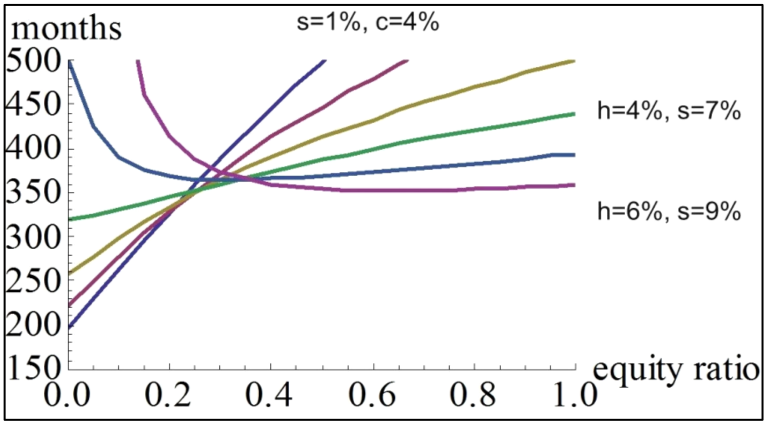


Figure 1. The impact of parallel interest rate shifts on process durations in the base case.

Before we explore interest rate risk in more detail we have a closer look at the issue when saving does make sense. The following consideration proves helpful. At the beginning of each period during the savings process the consumer may wonder whether it is better to save for another period or to take the loan and buy the house. In order to decide we can compare the wealth increase during the next period. Be S the accumulated capital at the beginning of the period. Until the beginning of the next period the consumer will add a further rate of $A - R$ and earn interest. This wealth increase is $(S + A - R) \cdot s + E - R$. In case she opts for the purchase the consumer does not need to pay a further rent but adds a full rate A to the capital. Therefore, a loan of $X - S - A$ is necessary to finance the home. During the subsequent period interest must be paid and instead of a rent the maintenance cost M. The wealth increase is $A - R - (X - S - A) \cdot c$. A further period of savings makes sense if $(S + A - R) \cdot s + E - R \geq A - R - (X - S - A) \cdot c$. Rearranging terms results in $(S + A) \cdot (s - c) \geq M \cdot (s + 1) - R - X \cdot s$. Dividing by X reveals

$$\frac{S+A}{X}(s-c) = q(s-c) \geq m(s+1) - r - s \quad \text{or} \quad q \geq \frac{r+s-m(s+1)}{c-s}$$

A credit rate typically is larger than a savings rate, such that $c - s$ is positive. A positive q therefore requires $r+s \geq m(s+1)$. Hence, saving is best if the monthly costs of ownership (maintenance + credit rate) exceed the costs of renting (rent + compounding). Owning a house provides additional benefits like the ability to enter into a longer-term housing services contract, customize the residence, and pledge the house as collateral. This *convenience yield* (Thomas & Savickas 2013) could be included in our model by reducing the maintenance costs and further supports early lending. Additionally, real life consumers who plan to buy a house often decide to rent comparably cheap while saving such that m is lower than assumed here and the relation fulfilled. In this case, any savings period will increase the total process duration. The time optimal decision would be to buy immediately. However, this argumentation only holds in case of stable interest rates. Interest rate risk sets an incentive for initial saving as explored in the next section.

Process durations with interest rate risk

Sensitivity of process durations to interest rate jumps

As a first step we analyze the sensitivity of process durations to interest rate jumps. We consider the base case process as specified above, but allow for a sudden rate increase during the process. After this increase rates remain stable until the process terminates. Savings and financing rate rise by the same amount such that the spread is unchanged. If the jump occurs during the savings period, the consumer will earn the higher rate from the next period onwards. For the later loan the higher rate will apply. In case the jump occurs during the financing period we likewise assume that the higher rate applies immediately in the subsequent period. Because the total payment A is fixed, the debt repayment is reduced and the financing process will take more time. With this, we assume variable rates and a flexible repayment scheme.

Naturally, the sensitivity with respect to interest rate jumps strongly depends on the equity ratio. During the financing period a rate increase has both a positive and a negative effect. The remaining savings time is shortened, the financing period extended. If a single rate jump occurs it is better for the consumer if it comes early. An upwards rate jump during the financing period always has a negative effect. The later the jump the better for the house owner. Downward rate jumps will have the exact opposite effect. We therefore only discuss rate increases.

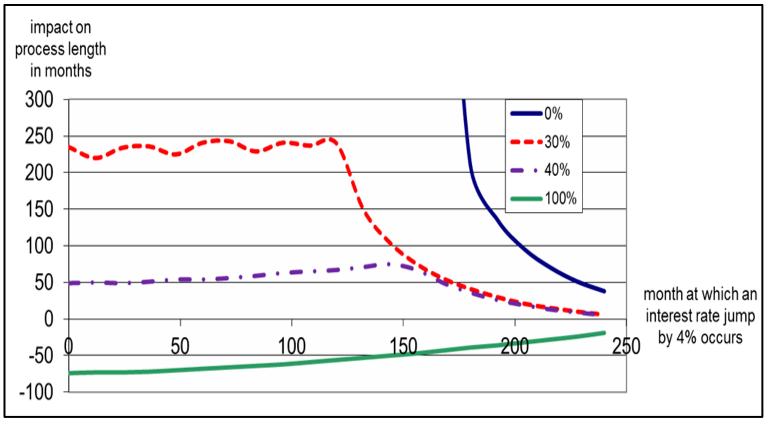


Figure 2. Impact of interest rate jumps on process durations for equity ratios 0%, 30%, 40% and 100%

Figure 2 shows the results of our exemplary calculations. Assuming the base case parameters we model a single rate jump of 4%-points from s = 4% and c = 6% to s = 8% and c = 10%. The jump may occur at the end of each year (i.e. after 12 months or multiples thereof). We calculate the impact of such jumps on the process time for each year and different equity ratios. The solid lines in Figure 2 denote the extreme cases of 0% equity (upper line) and 100% equity (lower line). With no equity the rate increase easily makes the loan unaffordable (i.e. process time longer than 150 years = 1,800 months), the process time reacts highly sensitive. For equity ratios up to 20% only rate jumps occurring rather late may be compensated by a reasonable time increase. The full equity strategy, in contrast, profits significantly from a rate increase.

The interesting cases are the medium equity strategies. The dotted line in Figure 2 shows the sensitivity of a 30% equity strategy. Rate increases during the savings phase (up to 120 months) trigger nearly the same increase of around 230 months (19 years) no matter when the jump occurs. The sensitivity of a 40% equity strategy (dashed line) shows a similar pattern but at a much lower level. A jump during savings increases the process only by around 60 months (5 years). Sensitivity is highest shortly before the home purchase. This is plausible, because at this time higher rates do no longer help much for the savings but affect the whole financing time. With loan repayments the rate sensitivity decreases steadily and rather fast.

Historical simulation on interest rates

Our interest rate simulations use the term structure model proposed by Svensson 1994. In this parameterized model the spot curve $s(t)$ is given as a closed form analytical function, which depends on six parameters. A big advantage of such type of model is that the function can be evaluated flexibly at each time horizon t. Additionally the German central bank estimates daily parameters based on German government bond yields, Schich (1997). The time series of these parameter estimates from 09/1972 to present is available at www.deutsche-bundesbank.de. Hence, a time series of the entire German yield curve is provided.

Figure 3 shows the development of the 1-year (lower bold line) and 10-year (upper thin line) spot rates as reconstructed from the Bundesbank Svensson parameters. We observe significant swings with pronounced peaks and troughs, strong variations in curve steepness and a steady decline of rates during the last twenty years. Accordingly, a historical simulation runs through a wide variation of interest rate scenarios. We calculate process durations for our model process starting in each month of the data history. Varying the equity ratio reveals important characteristics of the interest rate risk. We first consider variable rates, which adjust monthly to market rates. Afterwards, we explore the impact of fixed interest rates for consecutive periods as usual in practice.

Figure 4 shows results. All charts have the same scaling and are directly comparable. A strategy with low equity (upper left) clearly benefits from low interest rate levels as indicated by the decreasing line. However, low equity strategies starting before the interest rise in the mid 1980s (around month 200) often became unaffordable. This confirms their high interest rate sensitivity as discussed above. Process durations for medium equity strategies appear remarkably stable despite the significant swings in interest rates. The 40%-strategy just varies between 21.5 and 23.5 years (260 to 280 months). This confirms our observations for parallel interest rate shifts, where medium equity strategies appeared nearly insensitive to interest rate risk. A high equity strategy (lower right) benefits from the high interest rates in the beginning of the data sample and show the opposite behavior compared to low equity strategies. Interestingly, the strategies only terminate when starting at rather high rates. An 80%-strategy only was possible during the 1970s. This clearly indicates that financing a home necessarily requires borrowing in an interest rate environment as observed in Germany during the last 30 years. The currently extreme low level even enforces rather high levels of debt. However, this also provokes significant interest rate risk.

Figure 5 shows process times when rates are fixed for consecutive time periods during the financing phase. We compare 1 year up to 15 year fixing periods as usual in practice, European Central Bank (2009). Interest rate fixing significantly increases the variation of process times. Hence, interest rate risk is more pronounced with rate fixing. Indeed, optimal mortgage choice is both important for home financing and a very complex decision (van Hemert (2010); Campbell & Cocco (2002)). Presenting the risk in a time oriented perspective might help consumers to better understand its relevance and potential impact.

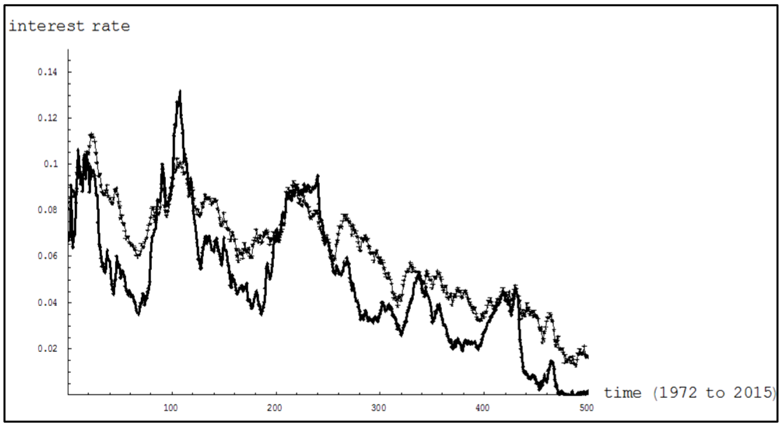
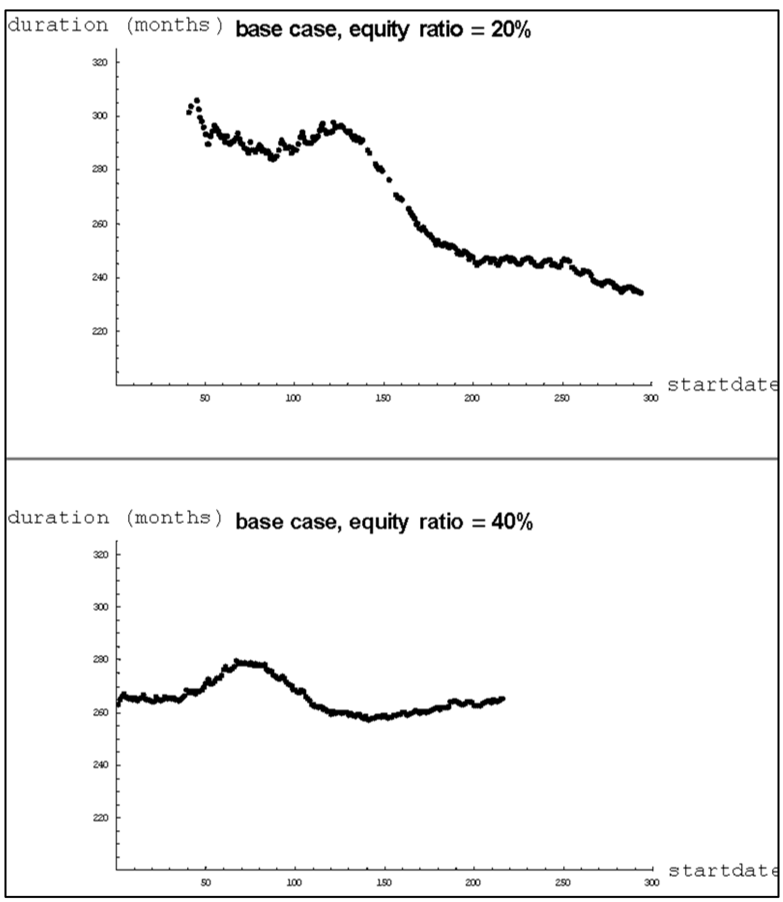


Figure 3. Development of German interest rates from 1972 until 2015 (1 year and 10 years spot rates)



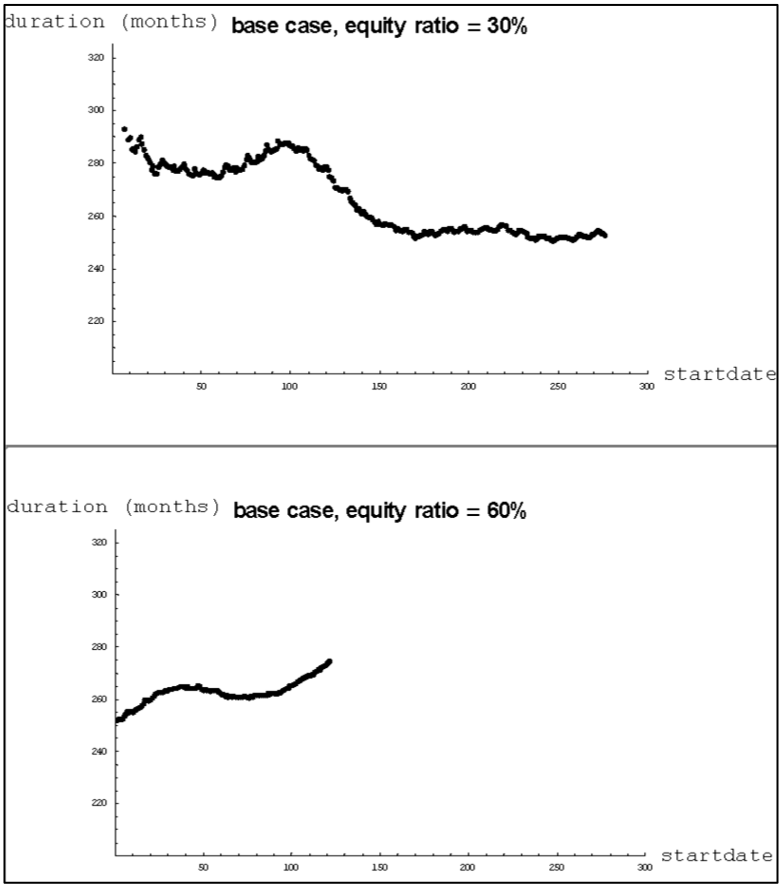
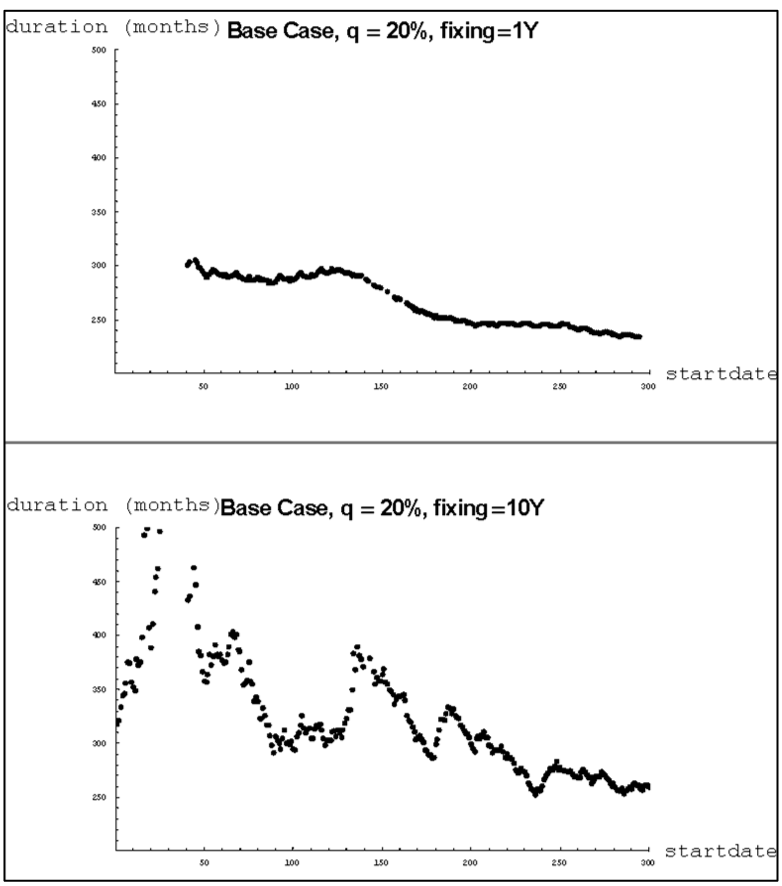


Figure 4. Process durations for different equity ratios, monthly from 9/1972 (month 0) to 8/1997 (300)



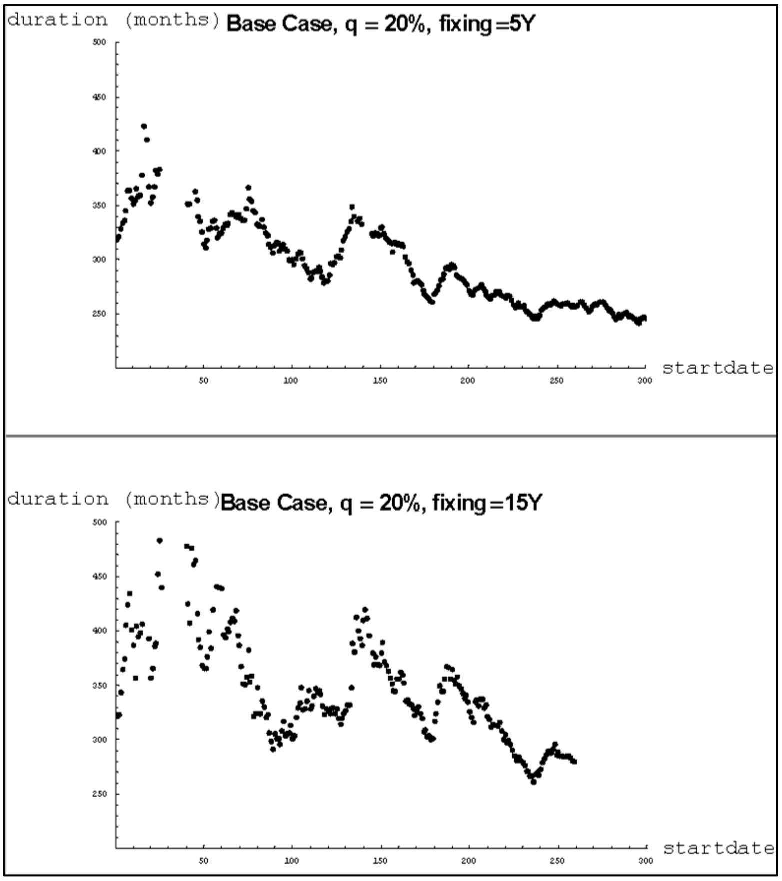


Figure 5. Process durations for q=20% with different rate fixing periods, monthly from 9/1972 to 8/1997

Conclusions

We present a comprehensive yet manageable six parameter model for an important financial decision. Exploring interest rate risk for housing finance we analyze the decisive role of initial savings and the equity ratio using historical simulations. Risk is expressed in a time oriented perspective what well reflects the situation of an income restricted consumer but has seldom been studied before. With this we contribute to a better and more comprehensive understanding of interest rate risk in housing finance.

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