ALM Risk Penalty Methodology

In short, Asset Liability Management (ALM) within a retail bank comes down to managing interest rate risks stemming from saving accounts and mortgage loans. Saving accounts (or other types of bank accounts) allow clients to deposit or to withdraw their money. These accounts are marked as liabilities for the bank. Mortgage loans on the other hand, are loans sold by the bank to clients for financing (residential) property. The (residential) property itself is used as collateral. Mortgage loans are marked as assets for the bank. In an ideal world a bank uses the saving accounts to finance the mortgage loans. In absence of duration mismatches, withdrawal of savings, defaults on mortgage loans, prepayments and interest rate fluctuations, a risk-free strategy could be defined. The strategy uses the savings accounts for financing the mortgages. The bank pays the account holder a certain saving rate. At the same time, the bank requests a mortgage rate equal to the saving rate plus a spread. In this strategy, the bank earns the spread.

Due to different market and non-market (or behavioral) uncertainties, setting-up such a risk-free strategy does not hold. This implies a funding gap, i.e. other sources of funding are required to fund the mortgage loans implying interest rate risk. As a consequence ALM departments are occupied with interest rate risk management, maturity matching, treasury and (external) funding. In this white paper, one of these uncertainties on the radar of ALM is selected. The white paper will consider the risk related to missing interest rate income as a consequence of prepayment events. A prepayment event is a repayment of the notional of the loan other than mentioned in the contract. In some of the prepayment events, banks compensate themselves for the missed interest rate income by applying penalties to their prepaying clients. Since penalty methodologies are far from transparent and calculating incorrect penalty amounts or the inability to explain the calculations may lead to reputational damage, the theory and intuition is considered hereafter. Understanding the steps underlying the penalty calculations, enables management and front office to explain the matter in a transparent way to clients, higher management and regulator.

Main takeaways:

• The inability to explain the rational behind penalty amounts may lead to reputational damage;
• There does not exist a uniform correct penalty methodology;
• Penalty amounts charged to clients will heavily depend on the underlying assumptions and understanding them is crucial;
• Linear, bullet and level paying loans with similar loan characteristics will lead to different penalty amounts;
• Although the risk seems negligible, the implementation of an erroneous penalty methodology may result in missed cash inflows;
• RiskQuest has extensive knowledge both in modelling, data-cleansing and documentation with a special attention to the field of ALM.
Introduction

At origination of a mortgage loan, the mortgage holder agrees with the bank on the terms of the contract. The contract terms are binding and of importance in case of relocation of the mortgage holder, a (partial) prepayment or an interest rate reset. The most important characteristics of a mortgage loan captured in the contract are: notional of the loan, amortization type of the loan, reconsider period, (fixed) term of the loan, interest rate fixed period, mortgage coupon and the annual amount that one can prepay each year.

![Figure 1: Left the notional repayment scheme of a loan under the three different amortization types. Right the interest payment scheme of a loan under the three different amortization types.](image)

Three characteristics that are of particular interest for the topic in this white paper are: the prepayment type, the amortization type and the franchise amount. The prepayment type tells the bank the incentive of the client to repay on the mortgage loan. In general, one identifies the following prepayment events in the Dutch mortgage market: relocations, (external) refinancing, partial prepayments (referred to as curtailments) and reconsider events. The last event refers to reconsidering the offered mortgage rate during a predefined reconsider period. The amortization type indicates according to which payment scheme the loan will be repaid. The most well-known amortization types are bullet, linear and level paying\(^1\). Figure 1 shows the notional repayment and interest payment schemes for each of the amortization types. Note that for level paying loans the sum of the notional repayment and interest payment is constant for each period in time. The total periodically payment has the form of an annuity.

The franchise is the annual amount that one can repay on top of the contractual repayments without being penalized. The franchise amount is a fixed percentage of the original outstanding notional. In other words, the bank gives the client the option to annually prepay a fixed percentage of the original outstanding notional, free of charge, e.g. 10%. This embedded option – written to the client by the bank – has an economic value. In order to determine the value of the embedded options within a mortgage contract, a stochastic model for (future) interest rates is required which is not in scope of the current white paper.

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\(^1\) The Dutch terms are aflossingsvrij (bullet), lineair (linear) and annuitair (level paying).
A prepayment exceeding the franchise amount will, under certain conditions, be penalized. The next section examines the methodologies to determine the height of the penalty. It also provides illustrative examples.

**Missed (interest) cash flows**

In the most straightforward scenario, the client repays the contractual notional and interest payments in accordance with the mortgage contract. In that case, the bank has full transparency with respect to the future cash inflow. Thereby, the bank can perfectly monitor the interest rate risk metrics and set-up an appropriate hedge upfront. In reality, prepayment events introduce uncertainty with respect to the future cash inflows and hence risk for the bank. If a client pre-pays on his loan, the cash flow profile with the future interest income of the bank changes. Apart from the direct impact on the interest income of the bank, the hedge strategy is also affected.

In the Netherlands, a mortgage holder is allowed to foreclose the mortgage loan in case of relocation without being penalized. If one sells the (residential) property, the mortgage loan can be foreclosed without financial consequences\(^2\). The same holds for reconsider events. In case of (external) refinancing and partial prepayments however, a compensation is requested by the bank. Note hereby that the partial prepayment amount should exceed the franchise amount. Whenever multiple partial prepayment occurs within a year, the franchise amount is adjusted after each event. The events and the consequences from a penalty perspective are depicted in Figure 2.

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2 An exception is when the (residential) property decreased in value. In that case, the remaining loan amount after selling the property has to be compensated.
An incentive for external refinancing presents itself whenever the mortgage rates, quoted in the market, drop below the contract coupon rate. Conditional upon a lower mortgage rate regime, refinancing a mortgage loan will be beneficial for the client in two ways. First, based on the original fixed term period, the contract coupon after (external) refinancing is lower compared to the original contract coupon. Second, since the original fixed term period exceeds the remaining fixed term at moment of prepayment, the new contract coupon will be based on a shorter fixed term. For example, suppose a client obtained a mortgage bullet loan with a 10-year fixed rate period and a contract coupon of 5.00%. After five years, the client decides to refinance the loan internally. The current quotes for the 5-year and 10-year mortgage loans are respectively 4.00% and 4.50%. Although the current 10-year rate is lower than the contract coupon, the contract coupon after refinancing will be 4.00% since the remaining contractual fixed rate period is 5 years. The interest payment and notional repayment will be adjusted accordingly.

The previous example demonstrates the impact on the bank its interest rate profile in case of a refinancing. According to the contract, the bank receives interest cash flows of 5.00% for a period of ten years. Due to a refinancing event, the cash flows after year five diminish by 1.00% as depicted in Figure 3. Note that the rates first have to be converted in monthly rates since mortgage payments usually occur monthly.

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**Figure 3:** Illustration of the methodology underlying the penalty calculations; where \( c \) is the original monthly contract coupon and \( c^* \) is the monthly mortgage rate after the prepayment.

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3 Annual rates are converted into monthly rates by using the equation

\[
(1+r_{\text{annual}}(t)) = (1+r_{\text{monthly}}(t))^{12}
\]

or in terms of the monthly rates

\[
r_{\text{monthly}}(t) = (1+r_{\text{annual}}(t))^{1/12} - 1.
\]

Sometimes people use the shortcut

\[
r_{\text{monthly}}(t) = r_{\text{annual}}(t)/12.
\]
The penalty expression for a bullet loan

In case of a bullet loan the penalty amount the bank will charge its client, equals the present value of the missed future interest cash flows. The reasoning is as follows: suppose the bank has to sell a new similar mortgage loan immediately after the prepayment event, then it will only be able to realize an interest income equal to the current mortgage rate times the notional of the loan. Hence, the lost interest due to the prepayment event needs to be compensated for by the prepaying client. One can express the penalty for a bullet loan at time $t$ in a mathematical form as follows:

$$P_{\text{bullet}}(t) = \sum_{k=1}^{M} N(t)\Delta I(t)d(t)^k$$

Here $P(t)$ is the penalty amount at time $t$, $N(t)$ is the prepaid notional amount at time $t$, $d(t)$ is the discount factor, $M$ are the remaining payments within the fixed rate period and $\Delta I(t)$ is the difference in interest payments due to the prepayment event. For bullet loans it holds that $\Delta I(t) = c - c^*(t)$; with the monthly contract coupon rate $c$ and monthly mortgage rate after prepayment equal to $c^*(t)$. After rewriting and using the closed form expression for geometric series, one finds for the normalized penalty expression for bullet loans, i.e. $N(t)=1$:

$$P_{\text{bullet}}(t) = (c - c^*(t)) \sum_{k=1}^{M} d(t)^k = \frac{(c - c^*(t))d(t)(1 - d(t)^M)}{1 - d(t)}$$

Refer to the earlier example, $c=0.41\%$, $c^*(t)=0.33\%$, $M=60$ and $d(t)=0.9967$. The normalized penalty amount is 0.0435, i.e. for each 1 EUR penalty-bearing prepaid notional, the client has to pay 0.0435 EUR.

Note that the future cash flows are discounted against rate $c^*(t)$ and not the risk-free rate. Moreover, a flat interest curve is used instead of a forward curve. The amortization period of a mortgage loan is assumed to be 30 years. The penalty-bearing notional refers to the prepaid notional amount minus franchise amount. Each bank determines its own conditions. The conditions are captured in the terms of the mortgage contract. Therefore, differences may arise based on different assumptions.
The penalty expression for other types

Besides bullet loans, linear and level paying loans are the most common types. Until now the notional repayments have not been considered for calculation purposes where these are zero for bullet loans. For linear mortgage loans these are not of interest for the penalty calculation, since the notional repayments are not dependent on the contract coupon and hence equation [1] is still valid. Although the value of \( \Delta \bar{I}(t) \) depends on \( k \). For level paying mortgage loans, the notional repayments depend on the contract coupon via the so-called annuity factor \( a(c) \).

Equation [1] is extended with the notional repayment which penalty calculation accordingly. The normalized penalty equation (or penalty per EUR penalty-bearing notional) for level paying loans can be expressed as an analytical solution as follows:

\[
P_{\text{level}}(t) = \sum_{k=1}^{M} \left( \frac{N(t)}{a(c)} \right) - \left( \frac{N(t)}{a(c')} \right) d(t)^k = \frac{(a(c') - a(c))d(t)(1 - d(t)^M)}{a(c)a(c')(1 - d(t))}
\]

When one uses the parameter values of the example again, however this time for amortization types level paying and linear, the normalized penalty amounts are respectively 0.0309 and 0.0401. Penalties for the level paying and linear loan with the same characteristics are respectively 29% and 8% lower compared to the bullet loan. To give the reader more intuition of the sensitivities, the penalty per EUR penalty-bearing notional are plot as function of the mortgage rate after prepayment \( c^* \) (left graph) and as a function of the remaining payments \( M \) (right graph).

Figure 4: Left shows the penalty per EUR penalty-bearing notional as a function of the remaining payments within the fixed rate period. Right shows the penalty per EUR penalty-bearing notional as function of the current mortgage rate in the market, i.e. mortgage rate after prepayment. The penalty on the y-axis and the parameter \( c^* \) or \( M \) on the x-axis.

4 The annuity factor determines the monthly (annuity) payment of a level paying mortgage loan. The annuity factor is calculated as: \( a(c) = \frac{1 - (1+c)^{-T}}{c} \) where \( T \) is the remaining amortization period. Note that this is the combined interest and notional repayment.
The dependency of the penalty amount towards the market mortgage rate is intuitively straightforward. The smaller the mortgage rates observed in the market, the larger the penalty, with a limit around $c^*=0.00\%$. For the penalty as function of the remaining number of payments, one observes that the larger the remaining payments within the fixed rate period, the larger the penalty as expected. An interesting observation however is that the linear and level paying penalty intersect. The intersection is caused by the difference in amortization scheme and hence outstanding notional. Before the intersection the outstanding notional (and hence the penalty) of the linear loan exceeds the outstanding notional of the level paying loan. After the intersection the effect is vice versa.

**Conclusion**

The penalty formulas for the different amortization types give an expression for the penalty amount per EUR penalty-bearing prepaid notional. The differences in the amortization schemes result in different penalty expressions accordingly. Topics related to penalty calculations, not discussed in this white paper but very interesting are for example, the construction of the mortgage rates, including or excluding the net payment at the end of the fixed rate period in the penalty calculations, hybrid amortization types and prepayments that happened within a month.

The white paper introduces the environment of prepayment events, the penalty methodology, the penalty expressions and the intuition behind the formulas. Having a clear understanding of the penalty calculations decreases reputational risk. Moreover, it contributes to a transparent framework. RiskQuest understands the mathematics behind interest rate risk calculations, e.g. penalty calculations, and at the same time is able to explain the theory in common language.
RiskQuest is an Amsterdam based consultancy firm specialised in risk models for the financial sector. The importance of these models in measuring risk has strongly increased, supported by external regulations such as Basel II/III and Solvency II.

Advanced risk models form the basis of our service offer. These models may be employed in a frontoffice environment (acceptance, valuation & pricing) or in a mid-office context (risk management and measurement).

The business areas that we cover are lending, financial markets and insurance. In relation to the models, we provide advice on: Strategic issues; Model development; Model validation; Model use.