# Study on the costs and benefits of the different policy options for mortgage credit

## Annex D

### Description of early repayment and responsible lending and borrowing model

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October 2009

# Annex Cost-benefit analysis simulation model description

The model is used for the cost-benefit analysis of early repayment and responsible lending policy options.

## *Model overview*

### A cohort-wise mortgage sector model

The cost benefit analysis (CBA) is carried out with the help of a general equilibrium style model implemented in MS Excel. The model simulates an economy's mortgage sector by describing four stakeholder groups as representative agents, namely consumers, lenders, intermediaries and government with relevant output indicators. Consumers are further differentiated between prime and sub-prime.

A set of exogenous parameters calibrates the model to a specific Member State market identified before as being of interest for the analysis of certain legal regimes.

The model operates on the basic of individual cohorts, i.e. old loans are regularly amortized, prepaid or being defaulted on, and new loans are added to the portfolio, under yearly changing economic conditions.

There are 16 cohort – an 'inherited' portfolio in the 0 cohort, and additions in years 1 to 15. Results are obtained by taking net present values over 15 years.

### Effect of policy options, grandfathering

Policy options are transformed into binary (0/1) or continuous variables. Any change of policy variable values triggers an associated market variable reaction. For example, a reduction in the statutory early repayment compensation ceiling (e.g. from 3% to 0%) implies an increase in the early repayment option cost component of the interest rate by the market. The conversion of uncapped ARM into capped ARM (a 0/1 variable) brings about an interest rate markup via the market charging a cap premium. These interactions feed into the quantification of costs and benefits of stakeholders. The specific parameters of interaction between policy variables and market variables are empirically analyzed and the model assumptions presented in the relevant chapters on early repayment and responsible lending.

The policy changes take effect on January 1 of year 2 – year 1 serves to compute pre-reform (zero) cohort flows, which may be needed as benchmarks. Pre-reform legal regimes can be grandfathered, i.e. all policy changes implemented from January 1 of year 2 on do not apply to cohorts 0 and 1 (loans are originated on 12/31 of the year in question.

The baseline is a continuation of the legal regime governing the zero cohort for all new cohorts 1 - 15.

## *Model parameters and modules*

### Dynamic model parameters, interest-rate elasticities

The cyclical behaviour of long-and short-term interest rates, house price and consumer price inflation (CPI) as well as GDP growth is determined based on four economic scenarios. Please refer to the relevant chapter of the study for details.

Organic mortgage market growth, i.e. gross addition to the outstanding mortgage stock, is modeled as a function of long-term interest rates (negative), house price inflation (positive) and GDP growth (positive) derived from those scenarios.

We allow for mortgage demand and supply reactions to changes in the level and composition of interest rates.

In the dimension of interest rate risk protection, the model offers three product types – ARM, callable FRM and non-callable FRM (or hybrid ARM) – each for prime and sub-prime borrowers, i.e. in total six products. Demand for the three levels of interest rate protection associated with the products can be assumed either as constant (reflecting current market shares in the Member State, the default in the early repayment cost-benefit analysis) or as reacting to the relative interests rates of the three products (the default in the responsible lending analysis).

Relative interest rates are determined by the mortgage yield curve (interest rate difference between ARM and non-callable FRM) and the prepayment options price (interest rate difference between non-callable and callable FRM), as well as credit costs charged by lenders. The latter are assumed to be lower, the greater the interest rate risk protection value of the product is for consumers, and vice versa.

Lenders may also be modelled to either react to a yield curve of funding costs, which is determined by the risk-free yield curve (government debt) plus agency costs (issuer credit premium). They adjust their liability mix between short- and long-term funding – when the yield curve steepens, more short-term funding will be used - or keep a constant short-long liability mix. Lenders with small interest rate sensitivity of their short-long-funding mix or generally long liability maturities are labelled as ‘mortgage bank’, those with the opposite assumptions ‘universal bank’. Funding strategy changes do only affect lender profit, loan supply itself is assumed to react perfectly elastically to demand changes.

### Static model parameters

A first set of parameters sets the relative income levels of prime and sub-prime borrowers, with prime normalized to 100. Income growth then depends on GDP growth from the scenarios, with incomes of sub-prime borrowers displaying higher volatility (e.g., twice the

level of growth rates – in both directions, negative and positive) compared to those of prime borrowers.

A second set of parameters reflects loan underwriting criteria: house price-to-income ratio, loan-to-value (LTV) ratio and amortization schedule are determined, for prime and sub-prime portfolios each. With these assumptions on the interest payment, debt service and income paths, and the loan product being selected, the debt service-to-income ratio (DTI) becomes endogenous and a continuous variable. Similarly, by combining house price growth and amortization schedule we arrive at the current loan to value ratio of a financing.

Both current debt service-to-income and loan-to-value are identified by cohort by loan product and by credit (sub-prime vs. prime), which yields six diagonal matrices representing six subportfolios with current performance indicators. Via a transformation function reflecting their contribution to default risk, they are combined linearly to a default indicator (see credit risk module discussion below).

A third set of parameters determines mortgage loan pricing. The interest rate for each of the products is decomposed in four components, each of which can be calibrated separately: 1) an option-adjusted price reflecting administration costs (constant for all products) and the yield curve (ARM vs. FRM), 2) an early repayment option premium (callable vs. non-callable FRM), 3) a general credit risk premium (prime vs. sub-prime credit), and 4) a product-specific credit risk premium or discount for the six products reflecting the protective impact of interest rate risk protection via reducing default risk.

- For example, a sub-prime ARM product will fetch no yield curve and ERP option premium while containing a general sub-prime credit risk premium and a specific sub-prime ARM premium, reflecting the greater vulnerability of sub-prime borrowers to interest rate shocks.
- In another example, a prime callable FRM product will fetch both a yield curve and a prepayment option premium, but a smaller general credit risk premium (for prime risk) and a small or even negative specific credit risk premium, as the callable FRM provides the greatest level of interest rate risk protection.
- If a sub-prime borrower decides to chose a more protective (but more expensive) instrument than ARM, say non-callable FRM, he benefits in terms of a lower credit risk premium. However, in most yield curve constellations the net impact will still be a cost increase.

A fourth set of parameters allows for developing additional lender characteristics: initial capital ratios, agency risk premia (credit default swap costs), administration costs and provisioning / dividend policies. We do not vary those assumptions for the purposes of this study.

A fifth set of parameters describes the legal foreclosure regime.

- Foreclosure is instantaneous (i.e. no debt restructuring) once the stress indicator triggers are hit (see credit module discussion below).
- Recovery value is defined as current house price minus the legal and registration costs charges associated to a foreclosure (in % of the foreclosure sales price).

- Residual debt is defined the difference between outstanding debt and recovery value.
- We also model lender gains from the insolvency regime via the period over which residual debt must be serviced by the borrower through wage garnishment (discharge period) and the share of wages that is permitted to be garnished in such case. The present value of such additional proceeds is increasing lender recovery value.

**Table 1: Default model parameter assumptions**

| Credit risk | | Interest rate risk, amortization | |
|---|---|---|---|
| **House price to income ratio*** | | **Contractual maturity** | 40 years |
| Prime | 3 | **Zero call protection early repayment costs** | |
| Sub-prime | 4 | Early repayment option costs | 0.434% |
| **Initial loan-to-value ratio*** | | Foregone intermediation profit costs | 0.065% |
| Prime | 80% | **Early repayment parameters** | |
| Sub-prime | 90% | Non-financial early repayments | 3% |
| **Debt service-to-income ratio, critical values** | | Refinancing incentive elasticity (FRM) | -5 |
| Stress indicator threshold | 30% | Reinvestment loss calculation maximum | 10 years |
| Stress indicator weight* | 50% | **ARM cap costs** | |
| **Loan-to-value ratio, critical values** | | Formula-based, see text | 0.5-2% |
| Stress indicator threshold | 70% | **Other cost items** | |
| Stress indicator weight* | 50% | **Loan administration costs** | |
| **General credit risk costs** | | Cost to lenders | 0.45% |
| Prime | 0.17% | Margin charged to consumers | 0.50% |
| Sub-prime | 0.40% | **Lender agency costs** | |
| **Product-specific credit risk costs, ARM** | | Lender credit default swap costs | 0.10% |
| Prime | 0.33% | | |
| Sub-prime | 0.60% | **Foreclosure parameters** | |
| **Product-specific credit risk costs, capped ARM** | | Legal foreclosure costs % of house price | 20% |
| Prime | 0.165% | Statutory discharge period* | 5 |
| Sub-prime | 0.30% | Wage garnishment ratio prime | 50% |
| **Product-specific credit risk costs, non-callable FRM** | | Wage garnishment ratio sub-prime | 40% |
| Prime | 0.00% | **Rental investor agency costs** | |
| Sub-prime | 0.00% | Rental investor credit default swap costs | 0.50% |
| **Product-specific credit risk costs, callable FRM** | | | |
| Prime | -0.12% | **Intermediaries** | |
| Sub-prime | -0.31% | Profit margin % of new origination volume** | 0.50% |
| **Sub-prime income** | | Share of intermediary fees borne by lenders | 100% |
| Income level % of prime, initial | 60% | Market share of intermediary origination | 50% |
| Income growth % of prime growth | 200% | **Net present value discount rate** | 5.5% |
| | | | |
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***Source: Finpolconsult.***

Notes: *modified for the responsible lending simulations, see text.**New origination = organic growth (exogenously determined by economic scenarios) plus early repayments.

For example, a long discharge period will minimize credit losses by lenders while adding to consumer credit costs, and vice versa. High legal foreclosure costs mean reduced consumer and lender benefits while benefiting lawyers.[1]

A sixth set of parameters models the opportunity costs for consumers concerning the alternative to homeownership, renting. The model assumes a 'corporate' housing finance

[1] The model also allows for a litigation risk factor that represents the likelihood that a consumer can succeed in rejecting a lender's claim of residual debt (e.g. due to misleading advice being given by the lender). We do not use this feature in our calibrations.

subsector of rental investors. Rents charged are a function of the long-term interest rate, a credit cost premium imposed on rental investors and the house price level.

Credit premiums for rental investors are calibrated below sub-prime but above prime (consumer) levels (non-callable FRM assumed). This provides the following choice for a sub-prime borrower, for example: he may borrow for higher interest rates, become a homeowner and reap a capital gain on his invested equity, if any, in return, or he may rent for lower rents without being able to reap a capital gain.

The model also describes the characteristics of the intermediary sector, whose profits are determined by a fee profit margin multiplied by market share in origination (0.5%*50%) by the volume of new originations - organic growth plus prepayments. In addition, the share of intermediary fees borne by borrowers (vs. lenders), and the intermediary market share in total originations can be adjusted. Thus we limit the analysis to one-off intermediary profit levels without feedback effects, e.g. from portfolio performance in the form of ex-post reduced (trailing) fees when defaults increase.

All parameters are fed into five sub-modules, which are interlinked: a prepayment model, a default model, a models aggregating the former into the total portfolio (after default, amortization and prepayments), and two models describing lender and borrower economics.

## The early repayment module

Early repayment behaviour is influenced by the refinancing incentive (difference between current interest rates and interest rate at time of origination), the elasticity of financial prepayment behaviour to a given refinancing incentive and the level of non-financial prepayments (moves, inheritances, etc.). The latter is assumed to remain constant.

There are three early repayment sub-modules, one for each of the main product classes ARM, callable FRM, non-callable FRM (or hybrid ARM). The refinancing incentive is assumed to be zero for ARM. For the FRM, no distinction is made between the early repayment demand elasticities of prime and sub-prime borrowers to a refinancing incentive.

Policy changes of concern on January 1 of year 2 are the proportion of option costs that is passed on to borrowers as well as the early repayment compensation regime (reinvestment loss vs. foregone intermediation profit; caps, fees, and symmetry aspect) – in short, call protection.

Our main policy variable is the option costs pricing ratio – i.e. the proportion of lenders' early repayment option costs that is passed on to consumer via mortgage rates – is inversely correlated with the degree of call protection through compensations or fees – see early repayment section text for full detail of assumptions.

We assume that the options costs pricing ratio has a linear multiplicative impact on the consumer demand elasticity for early repayment with regard to the refinancing incentive. Borrowers will be more inclined to exercise the early repayment option when prepayment compensations or fees (call protection) are small and, inversely, a higher interest rate

incentive will be required for rendering early repayment profitable for the consumer when compensations or fees (call protection) are high.

- For example, when the demand elasticity of early repayment of an FRM with regard to the refinancing incentive is 5 then a loan that carries low levels of call protection, say option cost pricing ratio 80%, will have a combined elasticity of 4, and a loan that carries high levels of call protection, say option cost pricing ratio 0%, will have a combined elasticity of 0% (i.e. only non-financial prepayments occur).

We assume that prepaid amounts from old cohorts do not leave the system and are simply enhancing the gross originations of the newly originated cohort in the given year.

The outcome of the early repayment model is a diagonal matrix of conditional prepayment rates (CPRs) for each product for each cohort for each year that translates into a corresponding portfolio survival matrix.

## The credit default module

The default model starts by computing current debt service-to-income ratios and loan-to-value ratio (i.e. the home equity position) for each of the product sub-markets by loan cohorts and year.

- For example, when house prices fall and initial underwriting loan-to-value ratios have been high, borrowers are likely to be confronted with a high current loan-to-value ratio (if in excess of 100% 'negative equity') and are more likely to default than those with lower initial underwriting loan-to-value ratios or with house prices that have not fallen as much.

- Similarly when the debt service-to-income increases vs. initial values, e.g. as a result of an interest rate increase under an ARM contract translating it into a payment shock to the borrower, there is an increased likelihood of default.

We ignore other default drivers (e.g. fraud) and combine both current LTV and current DTI indicators to a simple probability of default (PD) estimate. That estimate is proportional to a stress indicator that is obtained in a non-linear additive fashion from the two default indicators:

- Critical threshold values are defined for both indicators, based on empirical evidence (e.g. 80% for LTV and 30% for DTI).
- If those values are surpassed, the default risk contribution by each indicator increases. This creates two convex indicator-default risk functions.
- We combine both functions additively into the stress indicator with the option to change weights for either indicator-default risk function.
- We set a floor to the default indicator to ensure that default is not avoided if only one of the two indicators is in good condition while the other is critical territory, i.e. any violation of either indicator threshold condition raises default risk.

The next step is calculating the loss-given-default (LGD) for the lender after taking into account the legal foreclosure regime that decides about how much residual debt remains to be serviced by the borrower (see above). The remaining non-recoverable debt is written off by the lender immediately.

The model then computes credit losses by multiplying probability of default, exposure at default (after regular amortization and prepayments) and loss-given-default.

The default model provides a tool to assess responsible lending policy measures of interest such as tighter underwriting criteria or interest rate caps on certain product types. For the purposes of this study we use:

- debt service-to-income thresholds (separately for prime and sub-prime borrowers) to take effect on reform day (January 1, period 2). A cohort exhibiting an initial debt service-to-income ratio higher than the threshold value will not be granted any mortgage loans at all and have to resort to renting.
- a cap set on mortgage rates for ARM to protect against interest rate increases. The way we model the cap is ensure an absolute interest rate limit, i.e. lenders will take a loss on their credit premium before the underlying index becomes limited. We do not assume that such losses can be clawed back – they will burden the lender's profit center.

The outcome of the default model is a diagonal matrix of default rates and loan survival for each product and credit for each cohort for each year.

## Portfolio aggregation

With new originations from organic growth and scheduled amortization of the loan products known in advance, we have now three diagonal matrices that we can combine to model the full portfolio in a total survival diagonal matrix: amortization, prepayment, default. This provides us with the quantitative basis for computing lender and borrower costs and benefits.

# *Cost-benefit outputs*

### Lender cost-benefit outputs

The lender economics section of the cost-benefit simulation model computes lender profitability. This is straightforward, as all relevant components of the lenders' profit and loss statement are determined by the model: foreclosure expenses, costs of funds, interest revenue on performing loans, revenues from wage garnishment, early repayment compensation revenues, and payments made to intermediaries.

For determining the costs of funds we assume that the liabilities financing the defaulted portfolio keep being financed by the lender until their maturity. In contrast, interest revenues can only be reaped from performing portfolio. The revenue base of non-

performing portfolio is wages garnished and foreclosure sales proceeds. Liabilities exceeding loan assets are invested at the short-term risk-free rate.

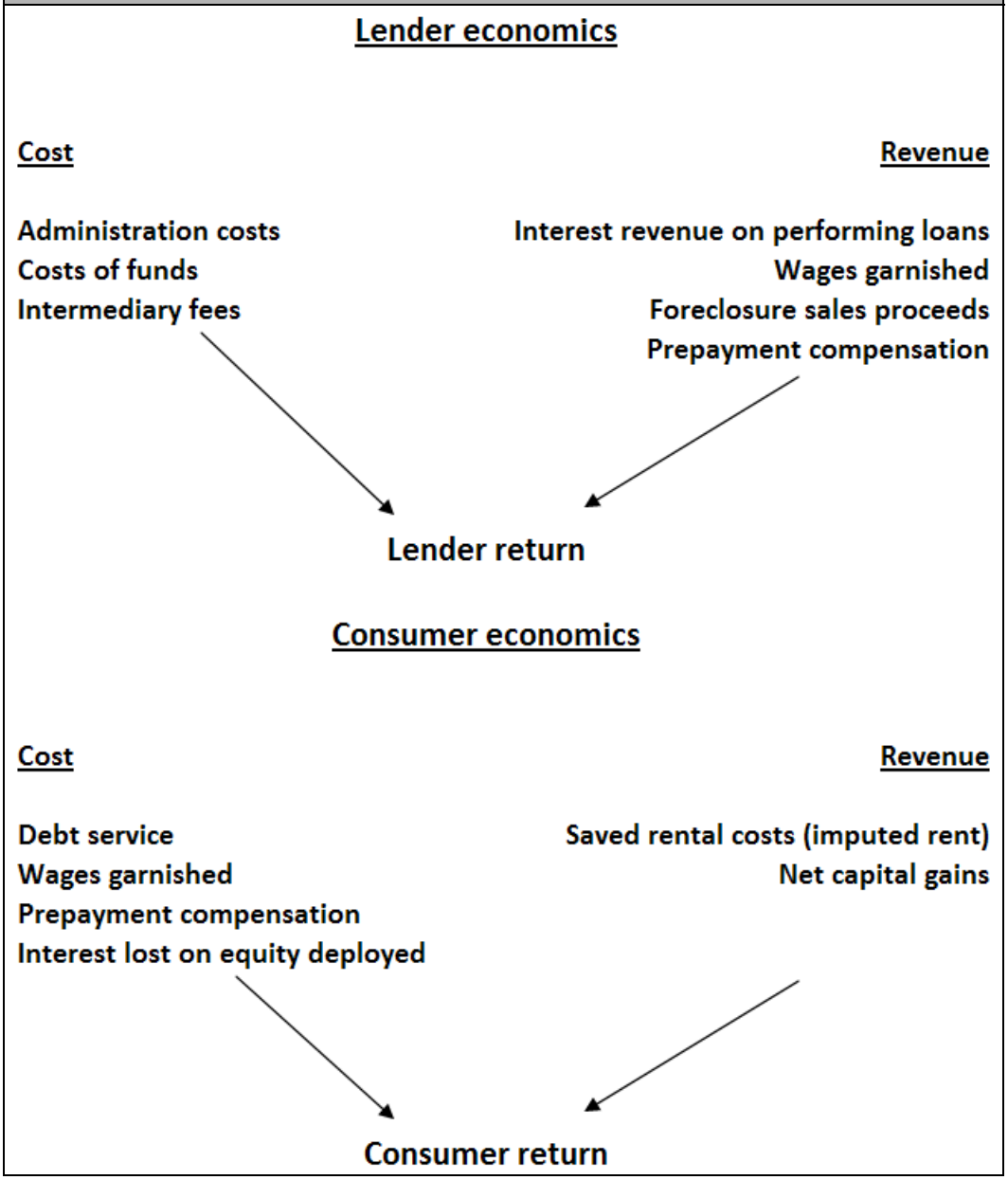
The impact of an early repayment is that prepayment fees and options revenues can be charged while the lender suffers a reinvestment loss and a foregone intermediation profit loss. The latter loss is limited to those loans that are externally refinanced (25%). The losses concerned are computed as the present value of applicable differentials (interest rates in the case of reinvestment loss, options-adjusted profit levels in the case of foregone intermediation profit) over the lower of the residual fixed-rate period of the loan and a calculatory maximum residual fixed-rate period of 10 years. For ARM always the calculatory maturity of 10 years is assumed. Reinvestment profits by lenders are booked as revenues; also negative options revenues are possible if ERP compensations or fees are above fair value, see text.

A lender profit centre sheet allows identifying and allocating profit and loss to the lender's corresponding operating activity. Three profit centres are interesting for the CBA, namely the early repayment option, the credit (default) option as well as general and administrative costs.

- The early repayment profit centre for instance juxtaposes revenues and costs as described above.
- The credit option profit centre is differentiated by the six products and derived from comparing credit spread revenues and foreclosure-related losses. We add an option for government to subsidize foreclosure losses (see below).
- The administration cost centre compares options adjusted price and administration costs; the difference is the basis for the computation of foregone lender intermediation profit.

The model offers alternative cost benefit measures such as return on equity or return on assets. For output calculations we take present values of the lender profit.

**Figure 1 Lender and consumer economics present in the cost-benefit simulation model**




*Source: Finpolconsult.*

**Consumer cost-benefit outputs**

In order to assess consumer cost and benefit the model computes and aggregates several time series:

- It compares borrowers' situation as a mortgagor to the alternative of renting, whose saved costs for renting a comparable unit are booked as consumer revenues ('imputed rent').
- A second source of revenue are capital gains reaped by keeping an equity position in the home. In the case of those defaulted borrowers where foreclosure proceeds did

not suffice to pay back the loan, that position is replaced by a negative figure - residual debt owed after a foreclosure, the flipside of the capital gains promise.
- A source of costs are the costs of credit, i.e. interest payments to banks, wages garnished from defaulted borrowers to service residual debt and intermediary fees paid.
- A second source of costs are foregone interest payments on the initial downpayment made when buying the house.
- Additional costs are wagnes garnished and early repayment compensation paid to lenders.

In this way we obtain a total return figure that is analogous to lender profit and a reasonable approximation of consumer net benefit from borrowing. We differentiate all figures between the prime and sub-prime (vulnerable consumer) portfolio.

**Intermediary cost-benefit outputs**

Intermediary profits are a linear function of market turnover – i.e. organic growth and prepayments and a per-case profit assumption. No losses of intermediaries are assumed as a result of misselling and the resulting litigation.

**Government cost-benefit outputs**

We do not model explicitly government – consumer relations. For example, there is no interest tax deductibility nor does government directly support defaulted borrowers.

In our model government only indirectly supports consumers, e.g. by setting the discharge period and the share of wages that lenders may garnish to affordable levels.

The resulting losses of lenders, however, can be directly assumed by government in proportion to their size. Consider this as approximating a bad bank solution for lender mortgage portfolios, alternative a direct cash recapitalization.

Government is compensated for bank recapitalization risk by receiving corporate income taxes when lenders make profits and may experience surpluses or deficit from her activities.

**Social cost benefit-outputs**

Consumer return, lender and intermediary profit, and government surplus or deficit are aggregated to arrive at a total single cost-benefit figure per scenario per case country per policy option. We later aggregate those results to the total of EU-27.