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Why APRC is misleading and how it should be reformed

Edina Berlinger*

Abstract: The annual percentage rate of charge (APRC) designed to reflect all costs of borrowing is a widely used measure to compare different credit products. It disregards completely, however, risks of possible future changes in interest and exchange rates. As an unintended consequence of the general advice to minimize APRC, many borrowers take adjustable-rate mortgages with extremely short interest rate period or foreign currency denominated loans and run into an excessive risk without really being aware of it. To avoid this, we propose a new, risk-adjusted APRC incorporating also the potential costs of risk hedging. This new measure eliminates most of the virtual advantages of riskier structures and reduces the danger of excessive risk-taking. As an illustration, we analyze the latest Hungarian home loan trends with the help of scenario analysis.

Subjects: Public Finance; Banking; Credit & Credit Institutions; Property & Real Estate Finance

Keywords: annual percentage rate of charge; adjustable-rate mortgages; foreign currency denominated loans; excessive risk-taking; regulation

JEL-codes: G18; G21; G28; G41



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PUBLIC INTEREST STATEMENT

The Annual Percentage Rate of Charge (APRC) is an important element of the regulation and consumer protection in mortgage markets. It was designed to help households to optimize their borrowing by making different loan products comparable. I show, however, that the calculation method of APRC is inherently wrong and the simple rule of minimizing APRC may lead to excessive risk-taking. In times of an increasing yield curve, consumers feel tempted to take up adjustable-rate loans with extremely short interest period; and also, in emerging countries, foreign currency denominated loans seem to be too attractive. Thus, if market conditions change, families may find themselves in incurable financial troubles. The problem of APRC calculation can be solved by incorporating the cost of risk-hedging into the formula. The proposed new measure would contribute to a more transparent and healthier mortgage market preventing the building up and consequently the painful burst out of housing bubbles.

1. Introduction

The disclosure of the annual percentage rate of charge (APRC) became mandatory first in the United States under the Truth in Lending Act (1968). This measure was designed to help borrowers to compare different credit products by reflecting all relevant costs of borrowing expressed as an annual percentage of the total amount of credit. In the European Union, the aim of the regulator was to promote a single consumer credit market and Directive (2008) set APRC into the center of consumer protection in all phases of the credit agreement (advertising, pre-contractual, and contractual) and harmonized its calculation across the member states. As a reaction to the latest developments in the credit markets, Directive (2014) improved and complemented the methodology of APRC.

Parker and Shay (1974) reported that the introduction of APRC in the US increased financial awareness significantly, though most borrowers remained unaware and continued to underestimate the costs of borrowing. According to their survey, the awareness of APRC depended mostly on the education level.

Since then, APRC has widely spread over due mainly to financial education campaigns and the proliferation of internet web pages specialized in the comparison and ranking of credit offers. The literature provides strong empirical evidence that price factors reflected in the APRC have a significant influence on the choice of the mortgage structure (Coulibaly & Li, 2009; Dhillon, Shilling, & Sirmans, 1987; Ehrmann & Ziegelmayer, 2014; Koijen, van Hemert, & van Nieuwerburgh, 2009; Vickery, 2007).

We argue, however, that APRC is misleading in its present form, as borrowers may feel it rational to minimize APRC and disregard risks and uncertainties. For example, if the yield curve is sharply increasing (as it is the case in most EU countries nowadays) adjustable-rate mortgages with very short interest rate period seem extraordinarily attractive due to their low APRC. Similarly, if the home interest rates are much higher than the foreign interest rates (as it was the case in many emerging countries), borrowers are tempted to borrow in foreign currency not least because APRC can be minimized in this way.

However, both in the cases of adjustable-rate (ARM) and foreign currency denominated (FXD) mortgages, borrowers run a significant risk of increasing payments linked to market factors like interest rates and exchange rates, which can be aggravated by unexpected changes in incomes, housing prices, etc. Of course, excessive risk-taking can sometimes be rational from the borrowers' and the banks' perspective, especially, if they expect to be saved through externally financed bail-out programs; however, this is far from being optimal at a social level.

One solution is to teach people to evaluate risks and uncertainties properly and to help them to solve complex optimization problems where costs, risks, and other aspects are taken into account, as well. A less ambitious but practical solution is to reform APRC calculation to reflect at least those risks that can be hedged in the forward or futures markets: i.e. interest rates and foreign exchange rates.

At the moment, APRC is calculated by assuming that present interest rates and foreign exchange rates remain fixed over the whole maturity of the loan. We recommend keeping the APRC formula but replacing spot interest rates and foreign exchange rates by their suitable futures or forward values. In this way, the cost of risk hedging would also be accounted for, and the virtual price advantage of riskiest structures would disappear. This modification would not solve all problems of excessive risk-taking in itself, as financially less educated people may keep focusing on the minimization of the initial monthly payment or non-tradable uncertainties are still not considered. However, the proposed new measure would certainly reduce the temptation to undertake too much risk.

In Section 2, we present the problem of excessive risk-taking in the form of adjustable-rate mortgages with very short interest rate period. The latest European trends are contrasted to the findings of the international literature of mortgage lending. In Section 3, we summarize the present regulation of APRC calculation in the EU and propose a new measure called risk-adjusted APRC which could effectively restrain both types of risk-taking and would make the corresponding risks more transparent. In Section 4, we derive a new general closed formula for the semi-elasticity of payments to the borrowing rate which turns to be equal to the modified duration of a similar but fixed rate loan. In Section 5, we illustrate the risk of adjustable-rate loans by a scenario analysis for the case of Hungary. We prove that under a realistic scenario consistent with the short term forecasts of the Central Bank of Hungary (inflation = 3%, real interest rate = 2%), monthly payments of adjustable-rate mortgages can increase by 49% by the end of the first interest rate period, which may put the ability-to-pay of the borrowers in serious danger leading to an increased systemic risk. We also demonstrate that during the last two decades in Hungary, it would have been at least as risky to borrow in home currency at a variable rate as in foreign currency (CHF) at a fixed rate. Hence, irresponsible risk-taking seems to reappear in new guises creating a new housing loan boom that can grow in a few years to become as detrimental as the previous one based on foreign currency borrowing. Finally, in Section 5, we summarize our observations and proposals.

2. APRC calculation and its side effects

In the aftermath of the global crisis of 2007–2008, various new financial regulations were invented and implemented worldwide to control systemic risk, to make economic institutions more resilient and to protect consumers; thus, banks' lending activity is much more regulated and transparent than before. Despite these measures, however, excessive risk-taking behavior may reappear in different guises, for example in the form of adjustable rate mortgages. This can be explained by many factors, but to a large extent, it can be due also to the perverse incentive inherent to the APRC calculation.

APRC calculation is regulated according to Directive (2014) throughout the European Union. The regulation aimed to make different types of credit comparable. APRC is calculated as an internal rate of return where future cash-flows C_t are the payments of the borrower at time t , and the present value PV is the face value of the loan:

$$PV = \sum_{t=1}^T \frac{C_t}{(1 + APRC)^t} \quad (1)$$

Although there are several complications regarding cost elements (e.g., interest rates, administration fees, mortgage registration) and time conventions, especially in credit agreements where there are different draw-down and repayment options, interest rate caps, grace periods etc., these features are exhaustively discussed and solved in the new directive.

Soto (2013, p. 56) formulates the main advantage of APRC as “... it puts the credit, its costs and time together, thus recognizing that these three elements are relevant in determining a comparable and uniform measure of the cost of the credit. In this way, the APR presents significant advantages over other measures of cost.”

However, an important assumption what makes APRC calculation totally misleading is that initial conditions are assumed to remain fixed. “In the case of credit agreements containing clauses allowing variations in the borrowing rate and, where applicable, in the charges contained in the APRC but unquantifiable at the time of calculation, the APRC shall be calculated on the assumption that the borrowing rate and other charges will remain fixed in relation to the level set at the conclusion of the contract.” (Directive, 2014, 16(4)) For example, in the case of an adjustable-rate mortgage, future cash-flows C_t in (1) are determined according to the present borrowing rate r , while in the

case of a foreign currency denominated loan, it is assumed that the foreign exchange rate X will be the same as today throughout the whole lifespan of the loan:

$$PV = \sum_{t=1}^T \frac{C_t}{(1 + APRC)^t} = \sum_{t=1}^T \frac{N_{t-1} \cdot r_0 \cdot X_0 + R_t \cdot X_0 + M_t}{(1 + APRC)^t} \quad (2)$$

where r_0 is the borrowing rate at $t = 0$, X_0 is the foreign exchange rate at $t = 0$ ($X_0 = 1$ if the loan is denominated in home currency), N_t is the nominal value of the loan, R_t is the repayment of the principal, and M_t is the administrative cost due at the end of period t . In this way, APRC reflects the charges of the loan assuming that market conditions remain the same.

However, in the case of adjustable-rate (or variable-rate or floating rate) mortgages (ARM), the borrowing rate r is not fixed for the whole maturity but only for a shorter period by the end of which it is reset in accordance with a predefined reference yield (benchmark or index) y . The spread s (i.e., the difference between r and y) can be fixed

$$r_t = y_t + s \quad (3)$$

or proportional to the reference yield

$$r_t = y_t \cdot k \quad (4)$$

where $s > 0$ and $k > 1$. Usually, the reference yield is the national interbank lending rate, or an interest swap rate, or a Treasury-bill or a bond rate, etc.

ARM loans are risky because nominal payments can change in line with the reference yield (cash-flow risk). Fixed rate mortgages (FRM) are risky, too, because the present value of the fixed nominal payments can change depending on the yield curve (present value risk). The choice between ARM and FRM loans is a choice between cash-flow risk and present value risk. The fundamental risk of an ARM loan is that a rise in the reference yield y increases the borrowing rate r according to (3) or (4), which increases the monthly payment, the payment-to-income (PTI) ratio (if the net income of the borrower does not keep pace), and consequently the probability of default. Shorter interest rate periods, especially with a proportional spread, are even riskier from this aspect.

It is clear from (2) that APRC depends on the interest rate period. For example, if the sovereign reference yield curve is steeply increasing, as nowadays in many countries, shorter interest rate periods go with significantly lower APRC, hence ARM structures look cheaper than FRM ones, which motivates borrowers to take more cash-flow risk than it would be optimal.

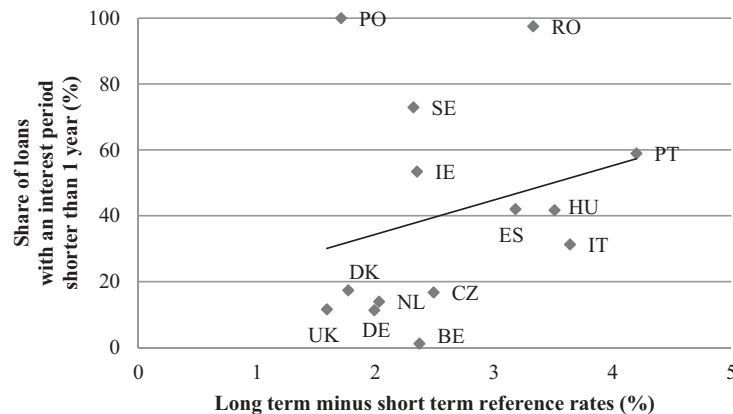
Financial awareness campaigns keep emphasizing that different loan structures should be compared against the APRC measure as it contains all relevant costs of borrowing (Parker & Shay, 1974; Soto, 2013). Banks are required to disclose APRC during the whole credit agreement process. Web pages providing information for borrowers also stress the importance of this measure. When comparing loan conditions, APRC is always in focus highlighted in large capital letters. Hence, borrowers are “trained” to minimize APRC even if it goes with higher risks.

Risky ARM loans can be especially popular in countries where the yield curve is sharply increasing. Using the cross-sectional data of those EU countries that are presented in the report of the European Mortgage Federation (2017), Figure 1 demonstrates that there is a positive relationship between the difference in the long term and short term reference rates and the share of ARM loans with extremely short (less than 1 year) interest rate period.

In the simple linear regression model in Figure 1, the R^2 is fairly low (0.063) reflecting that borrowers’ decisions are influenced by many other factors, as well, for example by supply-side constraints. For example, in Poland, even if the difference in the reference rates is relatively small,

Figure 1. Difference in the reference rates and share of ARM loans, new loans in Q2 of 2017.

Source: Report of the European Mortgage Federation (2017), Bloomberg



all the mortgage loans are ARM with an interest rate period of 3, 6 or 9 months simply because banks, for the sake of easy refinancing, do not offer fixed mortgage loans at all, and borrowers consider short period ARM loans as an “industrial standard”. If we take Poland out of the sample, R^2 and R become much larger: 0.29 and 0.54, respectively. Therefore, European mortgage tendencies are consistent with borrowers’ efforts to minimize APRC.

The driving factors behind risk-taking in the mortgage market were extensively investigated in the literature. Dhillon et al. (1987), Vickery (2007), Kojen et al. (2009); Coulibaly and Li (2009) and Ehrmann and Ziegelmayer (2014) found that when deciding on the loan structure, borrowers focus mainly on the pricing of the loans, thus they tend to minimize the APRC. Personal characteristics, however, may also play some role as according to (Dhillon et al., 1987) co-borrowers, married couples, and short expected housing tenures were even more for adjustable-rate mortgages; but other characteristics like age, education, first-time home-buying, and self-employment were insignificant.

Later studies investigated the impact of education and awareness on the mortgage choice more deeply. van Ooijen and van Rooij (2016) found that richer people with higher financial literacy take higher loans and higher risk perhaps because they know they can easily cope with financial problems should monthly payments arise. Posey and Yavas (2001) proved in their theoretical model that under asymmetric information, rational high-risk (low-risk) borrowers choose ARM (FRM); thus, their choice can serve as a screening mechanism for the lender. Kornai, Maskin, and Roland (2003) explained excessive risk-taking by the “soft budget constraint syndrome” i.e., rational market players expecting external financial assistance with high probability are prone to undertake too much risk.

However, it is hard to believe that the majority of homeowners choosing ARM loans in Romania, Portugal, Sweden, Ireland, Hungary, etc. (most of them with extremely short interest period), see Figure 1, are aware of the corresponding risks and can rationally afford to undertake them. There is strong empirical evidence that the predominance of ARM loans can rather be the sign of irrational risk-taking and a myopic attitude. Gathergood and Weber (2017) showed that borrowers with poor financial literacy and “present bias” tend to choose riskier mortgage structures. Bucks and Pence (2008), Woodward and Hall (2010), and Bergstresser and Beshears (2010) also found that borrowers do not fully understand or tend to underestimate the risk of changing reference rates.

The seemingly contradictory results of different empirical studies related to financial literacy and the mortgage choice can be reconciled if we define three levels of financial literacy. The first level is when borrowers know nothing about finance; the second level is when borrowers are aware of APRC and think that this measure is to be minimized in any circumstances; and finally, the third level is when borrowers evaluate costs and risks carefully and optimize their strategy at least in

these two dimensions. A change in financial literacy from the first to the second level may even increase excessive risk-taking as APRC minimization usually goes with risk maximization; while a step from the second to the third level probably decreases it. Therefore, contrary to the assumption behind multivariate regression models applied in the above studies, risk-taking behavior might be a nonlinear and even non-monotone \cap -shape function of financial literacy and different authors may report on different ranges of this function.

Based on the literature, we can conclude that the predominance of ARM loans with extremely short interest period can be the result of various reasons, but one of the major problems is that a mass of half-educated borrowers concentrate solely on APRC minimizing while they believe in acting rationally. In any case, rational or not, excessive risk-taking is suboptimal at a social level; hence, regulators should intervene on behalf of the wider society.

3. Our proposition: risk-adjusted APRC

It follows from (2) that APRC creates strong perverse incentives to borrow at an adjustable rate if the yield curve is significantly increasing and to borrow in a foreign currency if the yields in the foreign currency are significantly lower than in the home currency. As far as borrowers are minimizing APRC, their mortgage choice becomes accidental, which, depending on the actual market conditions, can lead to excessive risk-taking both at micro and systemic levels.

Given that APRC is a standardized tool developed explicitly to help borrowers to compare different loan contracts, it should be risk-adjusted. Borrowing is the reverse of investing. When evaluating different investment opportunities, it is evident that we use risk-adjusted performance measures and not only the expected return in itself. Similarly to this, borrowing opportunities should also be evaluated according to their riskiness, as well, and not only to their charges. A new measure is needed which comprehends both concepts (costs and risks) and defines a trade-off between them, too.

Directive (2014) prescribes to inform borrowers about risks, as well, but it is a separate and much less pronounced calculation. *“Where the credit agreement allows for variations in the borrowing rate, Member States shall ensure that the consumer is informed of the possible impacts of variations on the amounts payable and on the APRC at least by means of the European Standardised Information Sheet (ESIS). This shall be done by providing the consumer with an additional (stressed) APRC which illustrates the possible risks linked to a significant increase in the borrowing rate.”* (Directive, 2014, 16(6))

The risk is expressed as a result of a predefined stress test: *“Where there is a cap on the borrowing rate, the example shall assume that the borrowing rate rises at the earliest possible opportunity to the highest level foreseen in the credit agreement. Where there is no cap, the example shall illustrate the APRC at the highest borrowing rate in at least the last 20 years.”* (Directive, 2014, Annex II. Part B, Section 4(2)) However, this measure is quite difficult to understand, for example, it does not inform directly about the increment in the monthly payment and gives no guideline how to judge the relevance of the stress scenario, i.e., the borrowing rate reaching its 20-year maximum in the near future. Even if borrowers understood the concept of the stressed APRC, it is not obvious how to rank two conflicting measures at the same time, and they may have troubles in defining the trade-off between plain APRC and stressed APRC correctly. Another problem with the stressed APRC is that it is not accentuated in the initial advertising phase at all. As internet websites specialized in the comparison of mortgage loans do not indicate any risk measures, different loans can be ranked merely by the charges (APRC, monthly payment, administration fees). Stressed APRC appears only in small letters on the information sheet clients get from the bank in the pre-contractual phase, when they have almost decided which loan to take.

We propose to introduce a single measure, the risk-adjusted APRC to rank credit offers. The idea is that uncertain future variables (borrowing rates r and FX rates X) should be replaced in formula (2) by the suitable forward rates:

$$PV = \sum_{t=1}^T \frac{C_t}{(1 + APRC)^t} = \sum_{t=1}^T \frac{N_{t-1} \cdot f_{t-1,t} \cdot F_t + R_t \cdot F_t + M_t}{(1 + APRC)^t} \quad (5)$$

where $f_{t-1,t}$ is the forward interest rate for the period between $t-1$ and t , and F_t is the forward price of the foreign currency for the end of period t valid at the initiation of the loan contract $t = 0$. Although forward rates are not necessarily equal to the expected values of future rates, they can still be introduced into formula (5) since they are the so-called certainty equivalents (CEQ) of the future rates, i.e., the present values of the two are equivalent. The same CEQ method is applied during the valuation of derivative contracts (e.g., swaps), as well, see Hull (2012).

The corresponding article of the directive (Directive, 2014, 16(4)) should be modified accordingly. *“In the case of credit agreements containing clauses allowing variations in the borrowing rate and, where applicable, in the charges but unquantifiable at the time of calculation, the risk-adjusted APRC shall be calculated on the assumption that the borrowing rate and other charges will change according to their reference forward rates.”* The reference forward rates can be calculated from the reference yield curves or can be determined and published directly by the regulator on a daily basis.

The fundamental disadvantage of the plain APRC is that it contains not only the charges of the loan but also the risk premium the borrower gets in exchange for the risks undertaken. These risks, however, can be switched off with the help of forward contracts, as we suggest. In this way, eliminating the risk premium component and reflecting only the real charges, such as spreads and administration costs, the risk-adjusted APRC makes loan offers comparable. Note that this is true independently of the actual form of the yield curve.

A similar concept lies behind the well-known risk-adjusted performance measure Jensen-alpha α_i , as well, which indicates the excess return of the i th portfolio relative to the Capital Asset Pricing Model (CAPM):

$$\alpha_i = r_i - (r_f + \beta_i \cdot MRP) \quad (6)$$

where r_i is the average return of the portfolio, r_f is the risk-free rate, β_i measures the portfolio's market risk, and MRP is the average market risk premium (Black, Jensen, & Scholes, 1972). It can be easily shown that Jensen-alpha is the residual return of the portfolio if we properly hedge the market risk, i.e., switch off the risk-premium, for example by shorting index futures.

Consequently, risk-adjusted APRC can be interpreted similarly to the present plain APRC with the difference that it contains all charges including even the costs of risk hedging. It is a natural idea in finance to convert risks into costs (and vice versa), and the calculation is simple as far as the hedging instruments are traded and their prices can be determined, i.e., the markets are complete. Indeed, if clients hedged the risk of variable reference yields and FX rates in the forward (or futures) markets, and the costs of hedging were also considered according to (5), then the virtual advantage of adjustable-rate and foreign currency loans would disappear immediately.

The plain APRC (incorrectly) suggests borrowing always at the minimum of the term structure of interest rates. Therefore, in the case of an inverse (decreasing) yield curve, plain APRC favors fixed-rate loans to adjustable ones, i.e., it shows fixed-rate loans more advantageous even if they are relatively overpriced. This is a bias again, but much less dangerous than in the opposite case when the yield curve is increasing because households are inherently more sensitive to the cash-flow risk than to the present value risk. Moreover, households usually have the option to refinance their long term fixed-rate mortgages if market conditions change. In the case of a flat yield curve, forward rates equal the spot ones, therefore, plain and risk-adjusted APRC measures do not differ from each other.

In any case, the proposed risk-adjusted APRC has the advantage that it contains all relevant information to help decision making, does not alter mortgage decision from the optimum, impedes excessive risk-taking in the case of an increasing yield curve, and being independent of the actual form of the yield curve it makes different loan structures comparable.

4. The cash-flow risk of adjustable-rate mortgages

In this section, we derive a new closed formula which quantifies the cash-flow risk of adjustable-rate mortgages, hence helps borrowers to understand ARM loans and to make rational decisions.

Suppose an adjustable-rate loan to be repaid in equal installments C , where payments are due at the end of each period Δt , and the borrowing rate r is reset right after the payments. We are at the moment to determine the borrowing rate r for the next period, and we examine how the change in the reference yield y modifies the next payment C .

Consider first a loan of a similar structure, but with borrowing rate r fixed at the actual level for the whole maturity. The present value (or the price) of the loan P is

$$P = C \cdot A \quad (7)$$

where $A = A(r, T)$ is the annuity factor. The price sensitivity i.e. the percentage change in price for a unit change in yield is the so-called modified duration D^* (Hull, 2012):

$$\frac{dP/P}{dr} = -D^* \quad (8)$$

Clearly, $D^* > 0$ as an increase in the interest rate leads to a decrease in the present value. It follows from (7) and (8) that

$$\frac{dP}{dr} = -D^* \cdot P = C \cdot \frac{dA}{dr} \quad (9)$$

and $\frac{dA}{dr} < 0$. We can express $\frac{dA}{dr}$ from (9) as

$$\frac{dA}{dr} = \frac{-D^* \cdot P}{C} \quad (10)$$

Since $\frac{dA}{dr}$ depends only on r and T , (10) remains valid for adjustable-rate loans, as well (where D^* is still the modified duration of the fixed loan). For the adjustable-rate loan, (7) holds, as well, but now the present value of the loan P is fixed and the next payment C changes in accordance with the change of the borrowing rate r :

$$C = \frac{P}{A(r, T)} \quad (11)$$

Using (11) and (10), we calculate the semi-elasticity of C to r , i.e., the percentage change in payment for a unit change in the borrowing rate:

$$\frac{dC/C}{dr} = -\frac{\frac{dA}{dr}}{A} = \frac{D^* \cdot P}{C \cdot A} = D^* \quad (12)$$

Hence, by (12), the interest rate sensitivity of the payment is the same as the modified duration of a similar but fixed loan calculated at the present borrowing rate. Note that Király and Simonovits (2017) derive the same formula but in a more complicated form and they do not link it to the modified duration. Our approach also has the advantage that the modified duration is an intuitive, widely-used, and easily-computable measure.

Now, we show the effect of the reference yield y on the payment C . This effect depends on the spread algorithm, i.e., on the relationship between r and y . We consider the general formula

$$r = y \cdot k + s \quad (13)$$

where $k \geq 1$ and $s \geq 0$. This contains the special cases of (1) and (2), i.e., the fixed and the proportional spreads, for $k = 1$, $s > 0$, and $k > 1$, $s = 0$, respectively. By (13), we have $dr = dy \cdot k$. Hence, by (10), the semi-elasticity of C to y is

$$\frac{dC/C}{dy} = \frac{dC/C}{dr/k} = D^* \cdot k \quad (14)$$

It follows from (14) that proportional spreads are more dangerous than fixed spreads.

Of course, the first derivative of a function characterizes only the effect of a small change. It can be shown that C is a strictly convex function of y for the entire relevant domain, hence

$$\frac{\Delta C/C}{\Delta y} > \frac{dC/C}{dy} \quad (15)$$

Note that convexity is against the borrower; thus, the increases in the payments are larger than formula (14) suggests.

To sum up, the cash-flow risk of an adjustable-rate loan can be approximated by the modified duration of the corresponding fixed loan. It follows from (14) that a change of 100 basis points in the reference yield y causes approximately a change of $D^* \cdot k$ % in the payment. Thus, with zero interest rates, for a 20-year, fixed-spread loan, it is at least 10%, which can serve as a useful rule of thumb to quantify the exposure to the cash-flow risk of an ARM loan.

5. A case study of Hungary

Dollar-denominated loans used to be especially attractive in emerging countries for example in Latin America where local currencies were in a permanent appreciation providing significant risk premium for foreign investors. Yeyati (2006) showed that these financially dollarized economies suffered from lower and more volatile growth and a higher propensity to banking crises.

Cross-border debt flows increased rapidly worldwide in the run-up to the 2008 crisis. At the peak in 2007, bank-to-bank cross-border liabilities amounted to 20% of total private credit and over 30% of the GDP (Bruno & Shin, 2015). Between 2000 and 2008, households in several Eastern and Central European countries were also massively borrowing in foreign currency, but mainly in euro and Swiss franc. In these countries, FXD loans accounted for 50–80% of the total retail loan portfolio by 2007 (Király & Simonovits, 2017).

Hungary is an excellent example of a small open economy within the European Union but still outside of the eurozone experiencing a severe downturn along with the global crisis of 2017–2018 which was aggravated by the large Swiss franc denominated mortgage portfolio of the household sector (Berlinger & Walter, 2015; Király & Simonovits, 2017). At the beginning of 2015, Swiss franc debts were compulsorily converted to Hungarian forint, and presently, foreign currency denominated borrowing is highly constrained.

However, in the latest years, adjustable-rate mortgages become more and more popular which can be the sign of excessive risk-taking again. As in many countries, interest rates have reached their historical minimum, and it is difficult to predict how long this new regime of low interest rates may subsist. Therefore, to demonstrate the potential interest rate risk of adjustable-rate mortgages, we perform a scenario analysis, where we do not need to take a stand on the likelihood of the different scenarios as far as they are realistic and relevant.

Let us consider a 20-year Hungarian forint (HUF) denominated mortgage loan of 20 M HUF to finance the purchase of a new home of 30 M HUF ($\approx 100\,000$ EUR). Browsing the internet for the

best offers for different interest rate periods, we found the structures with the lowest annual percentage rate of charge (APRC) as presented in Table 1.

We suppose in Table 1 that the reference yield is the sovereign HUF bond rate (its yield to maturity) corresponding to the given interest rate period. Interbank rates (BUBOR) may also serve as a reference rate, and their values are somewhat different from treasury rates, but we disregard this distinction.

The latest home loan trends in Hungary are presented in Table 2.

In the case of home loans with longer maturity than five years, a vast majority (69%) of the Hungarian borrowers chose adjustable-rate structures in the last 18 months. More than half of these loans has 1-year or shorter interest rate period. If we consider the value of these contracts (second column of Table 1), these ratios are even higher. Typical PTI and LTV ratios are around 25% and 75%, respectively (Central Bank of Hungary, 2017b). As the current regulation stipulates that PTI and LTV cannot exceed 50% and 80%, respectively, LTV constraints seem to be more effective than PTI ones.

Scenarios are defined in terms of the reference yield y prevailing at the end of the first interest rate period. The output of the analysis is the increase in the monthly payment which has a direct effect on the family's living conditions, the ability-to-pay, and the default probability. We assume that the spread is fixed as in (3) and the Fisher-formula holds:

$$(1 + \text{inflation rate}) \cdot (1 + \text{real interest}) - 1 = \text{reference yield} \quad (16)$$

Regarding the inflation rate, we rely on the inflation target of the Central Bank of Hungary (2017a), see Figure 2.

Table 1. Mortgage offers in Hungary (20 years, 20 M HUF, 16.07.2017)

Interest rate period (year)	Lowest APRC	Payment per month (HUF)	Borrowing rate (r)	Treasury bond reference yield (y)	Spread ($s = r - y$)
1	2.38%	104 289	2.33%	0.09%	2.24%
3	3.72%	116 919	3.59%	0.78%	2.81%
5	4.14%	121 527	4.03%	1.77%	2.26%
10	5.23%	132 760	5.07%	3.08%	1.99%
20	5.90%	140 374	5.75%	3.61%	2.14%

Source: www.bankracio.hu, www.akk.hu

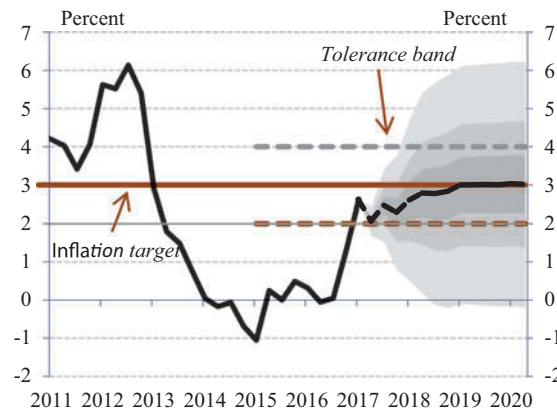
Table 2. New home loans in Hungary, 2016 and 2017Q1-Q2

	Number	Value
	(thousand)	(billion HUF)
Maturity ≤ 5 years	26	63
Maturity > 5 years	100	703
—adjustable-rate loans	69	556
—interest period is 1 year or shorter	35	304

Source: Central Bank of Hungary

Figure 2. Inflation rate target of the Central Bank of Hungary, June 2017.

Source: Central Bank of Hungary (2017, Figure C1-1)



The inflation rate is targeted to increase to 2.8% in 2018, to 3% in 2019, and is expected to remain stable afterward. Different colors represent probability zones of 30%, 60%, and 90%. Note the high uncertainty even for shorter horizons.

Regarding the real interest rate, official forecasts were not available; hence, we examined the past time series, see Figure 3.

Similarly to worldwide tendencies, presently, the forward-looking real interest rate is negative (−2.5%) and is at its historical minimum. In the last decade, the average real interest rate was around 2%, but the volatility was high (which is true for the whole last century). History also suggests that negative real interest rates are rare and only temporary. Based on these observations, we formulate five scenarios in Table 3.

The first scenario relies on the inflation target of the Central Bank (3%) and supposes an interest rate (0%) which is consistent with economic stagnation. The second scenario assumes the same inflation rate (3%), but the real interest rate is expected to return to its long term average (2%), which is consistent with normal economic conditions and is close to the 10-year average of the 1-year nominal interest rates. The third scenario takes the 20-year average (7.83%). Finally, the fourth and fifth scenarios reflect the 10-year and 20-year maximums (12.35% and 20.42%), respectively. Figure 4 presents the five scenarios relative to the 1-year Treasury-bill rate of the last 20 years.

Figure 3. Real interest rate in Hungary, 2007–2017.

Source: Central Bank of Hungary (2017, Figure C4-10)

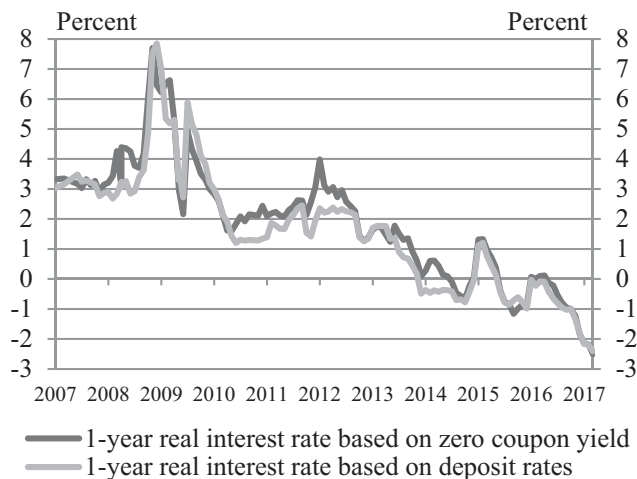
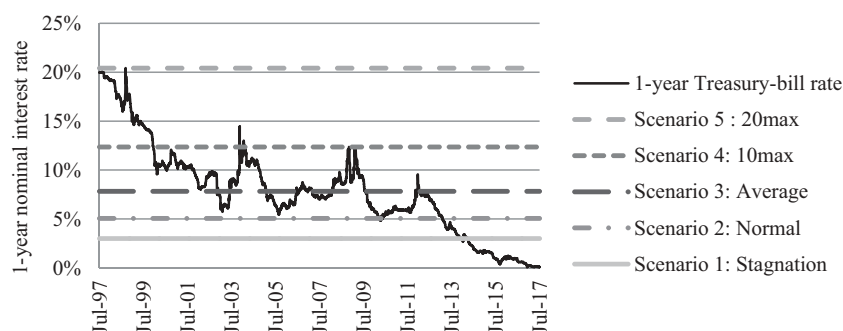


Table 3. Scenarios of the future level of reference yields

	Name	Reference yield	Remark
Scenario 1	Stagnation	3.00%	3% inflation and 0% real interest rate
Scenario 2	Normal	5.06%	3% inflation and 2% real interest rate
Scenario 3	20average	7.83%	20-year average of 1-year T-bill rate
Scenario 4	10max	12.35%	10-year maximum of 1-year T-bill rate
Scenario 5	20max	20.42%	20-year maximum of 1-year T-bill rate

Figure 4. The 1-year nominal interest rate and the corresponding scenarios, 1997–2017.

Source: www.portfolio.hu



Starting from the loan offers in Table 1, the results of the scenario analysis are presented in Table 4.

Table 4 shows the percentage change in the monthly payments at the end of the first interest rate period under different structures and scenarios. The shorter the interest rate period is, and the higher the reference yield rises, the more the monthly payment of borrowers increases for the next interest rate period.

If the interest rate period is only one year, then modest scenarios like 1, 2, and 3 increase the payment by 28%, 49%, and 81%, respectively, which puts the ability-to-pay of the borrowers in danger. If the net income does not change, then PTI increases by the same ratio, e.g., if it was initially 50%, then the new PTI will be 64%, 75%, or 91%, which makes the loan almost impossible to repay. Scenarios 4 and 5 are more likely to get realized in the longer run, but their effect can be detrimental even though the remaining maturity of the loan will be relatively shorter by then.

Table 4 above showed the scenario analysis for loans with a fixed spread. In the case of proportional spreads, however, values in Table 4 should be multiplied with $k > 1$; hence, multiplicative spreads embody an additional hidden risk.

According to the empirical literature, the default rate of ARM loans depends mainly on the payment-to-income (PTI) and loan-to-value (LTV) ratios which are related to the ability-to-pay and the willingness-to-pay, respectively (Connor & Flavin, 2015). Therefore, when evaluating the systemic risk in ARM lending, we have to consider also the net income of the households and the value of the real estate serving as collateral besides the mortgage payment. In normal conditions, the increasing inflation rate increases not only the mortgage payments but also the incomes and house prices, which provide a natural hedge against inflation risk. However, the extent and the timing of these effects may be very different, and it is not guaranteed that this relationship holds

Table 4. Results of the scenario analysis, percentage change in payments, constant spread

Interest rate period (in years)	Initial borrowing rate	Increase in payments at the end of the first interest rate period				
		Scenario 1 $y = 3\%$	Scenario 2 $y = 5.06\%$	Scenario 3 $y = 7.83\%$	Scenario 4 10 $y = 12.35\%$	Scenario 5 $y = 20.42\%$
1	2.33%	28%	49%	81%	139%	253%
3	3.59%	18%	36%	62%	109%	201%
5	4.03%	9%	24%	46%	85%	164%
10	5.07%	0%	9%	23%	48%	97%
20	5.75%	0%	0%	0%	0%	0%

for a short period and all borrowers. A macro-level shock of increasing oil prices, a stagnating economy, weakening home currency, sticky wages, etc. may create an extremely adverse situation for ARM borrowers.

Even if the probabilities of scenarios in Table 4 are believed to be low, borrowers are certainly not able to evaluate these risks properly, and a mass of households are taking too large speculative positions jeopardizing their living existence.

Though it is hard to compare the recently started ARM housing boom to the fully developed foreign currency debt portfolio at the end of 2008, the new tendencies can easily lead to a similar crisis. Table 5 presents how the new ARM loans of just the single year 2016 relate to the total foreign currency loan portfolio at the burst of the crisis which was accumulated for 4–5 years.

Note that adjustable-rate loans are as popular nowadays as foreign currency loans were in 2004–2008 not least because ARM loans help to reduce APRC by 3–4% points, which is considerable at the actual low level of borrowing rates. The increase of the payments under Scenario 2 (20-year maturity ARM with 1-year-long interest rate period) is roughly the same (49%) as the average increase was in the payments of CHF denominated loans (around 50%) which led to a deep and extensive social and economic crisis in 2008–2015 and ended up with massive bailout programs and a compulsory HUF conversion (Berlinger & Walter, 2015; Bethlendi, 2011; Király & Simonovits, 2017).

For example, in the case of the first loan of Table 1 where the initial maturity is 20 years, the interest rate period is one year, and the initial borrowing rate is $r = y + s = 0.09\% + 2.24\% = 2.33\%$, $D^* = 9.09$ at the end of the first year. This means that a 100-basis-point upward shift in the reference yield y (from 0.09% to 1.09%) will increase the payment C at least by 9.09% for a fixed spread and by $9.09\% \cdot 1.25 = 11.36\%$ for a proportional spread with $k = 1.25$ set by the Act on Fair Banking in Hungary.

If this loan was denominated in Swiss franc (CHF) and the borrowing rate was fixed, then the main risk factor would be the exchange rate X , i.e., the CHF/HUF rate. The payment C would be a linear function of the exchange rate X and a 1% change in X would cause exactly a 1% change in C . Hence, a percentage change in X has the same effect on the payment as $dy \cdot D^* \cdot k$ unit change in the reference yield:

$$dC/C = dX/X = dy \cdot D^* \cdot k \quad (13)$$

Therefore, in the case of the first loan in Table 1, a 100-basis-point change in the reference yield (1-year T-bill yield) is equivalent to 9.09% change in the CHF/HUF rate (or to 11.36% if we have a proportional spread). Let us examine which event tends to happen more frequently.

Table 5. Comparison of home mortgage booms in Hungary

	New adjustable-rate home mortgages in 2016*	Total outstanding foreign currency home mortgages at the end of 2008
Number of contracts	44 thousand	~500 thousand
Value of contracts	339 bn** HUF	~2300 bn** HUF
Value of contracts to households loans	73%	68%
Difference in APRC	3–4%	5–6%
Change in payments	49%***	~50%

* Long maturity (at least 5-year) ARM loans

** Billion is 10^9 according to the US terminology

***Estimation for a loan of 20-year maturity and 1-year interest rate period under Scenario 2 corresponding to normal economic conditions

(inflation = 3%, real interest rate = 2%)

Source: Central Bank of Hungary

As Figure 5 shows, in the last 18.5 years (CHF/HUF data were not available before 1999), the CHF/HUF rate increased by approximately 100% (doubled) while the 1-year T-bill rate decreased by approximately 100% (dropped to near zero). Supposing that both CHF returns and T-bill rate changes come from identical distributions, we can compare which stress event was more frequent in this past period: a more-than-100-basis-point increase in the 1-year reference yield or a more than 9.09% increase in the Swiss franc rate. In Table 6, we present the frequencies for the double and triple size stress events, too.

According to Table 6, the frequency of equivalent stress events tended to be the same or even higher in the T-bill than in the CHF market. This is especially true if we take more severe stress

Figure 5. Basis index of CHF/HUF rate and 1-year Treasury-bill rate, 01.01.1999–07.17.2017.

Source: www.portfolio.hu

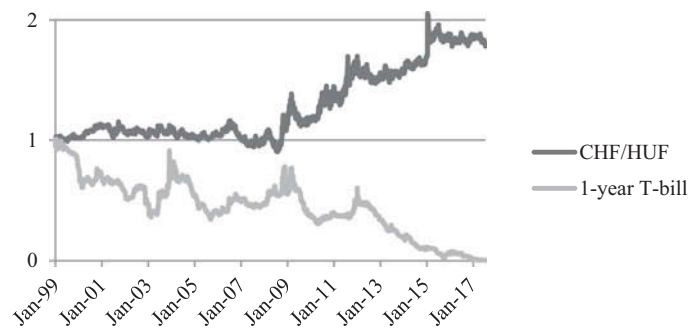


Table 6. Frequency of equivalent stress events, 01.01.1999–07.17.2017

	1 year T-bill rate	CHF/HUF rate
Stress event*	+100 basis point	+9.09%
Frequency	21%	25%
Stress event*	+200 basis point	+18.18%
Frequency	8%	8%
Stress event*	+300 basis point	+27.27%
Frequency	5%	0.4%

*Increase in 1-year T-bill or CHF/HUF rates within a year

events. For example, the maximum of yearly change in the T-bill rates was around 700 basis points (in 2012–2013) which is equivalent to $7\% \cdot 9.09 = 63.63\%$ change in the CHF rate, but the maximum of the latter was only 34% (in 2008–2009). Thus, in the last 18.5 years, it would have been somewhat safer to borrow in CHF but at fixed interest rate than to borrow in HUF but at an adjustable rate with 1-year interest period, especially, if the ARM spread is proportional and we consider the effect of convexity, as well.

At the moment, the outlook for ARM loans is worse than in the past, because interest rates are near to zero; hence, there is no more potential in decreasing. The best thing that can happen to ARM borrowers is that interest rates remain approximately the same. A significant increase in the reference yields may not seem very likely in the short run, but unexpected external shocks may boost the inflation and nominal rates in the longer run. Real interest rates being at their historical minimum, too, can be expected to increase, as well. If interest rates are expected to be as volatile in the future as in the past, then ARM borrowers should prepare for the worst scenarios.

In the above analysis, we concentrated only on the risk of increasing repayments, i.e., the cash-flow risk of borrowers which turned to be approximately the same for CHF fixed loans and home currency ARM loans. However, if we consider the risk of increasing LTVs, as well, foreign currency borrowing is riskier as the depreciation of the home currency increases not only the repayments but also the present values of the debts. This is not true for ARM loans because an increase in the nominal rates leaves the debts unchanged; moreover, rising inflation generally increases home prices; thus, LTVs tend to decrease in a stress situation.

However, when evaluating the overall systemic effects of ARM loans, we have to differentiate between families living in their homes and profit-seeking, highly-leveraged investors. In the latter case, ARM loans provide a natural hedge against inflation; indeed, since rising repayments are compensated by rising investment value and the cash-flow risk can be easily managed on the capital markets. However, in the case of simple households, increasing inflation is not immediately offset by increasing nominal incomes; therefore, their living existence is seriously menaced and decreasing LTVs help only the lending institutions. Thus, regarding the social effects, ARM loans can be as much detrimental as currency denominated fixed loans.

As mentioned before, replacing APRC by the proposed risk-adjusted APRC, the virtual advantage of adjustable-rate and foreign currency loans would immediately disappear. To illustrate this, let us take the spot and the one-year forward rate curves in Hungary, see Figure 6.

Assuming that payments are due only at the end of the year, we calculate the risk-adjusted APRC measures for the mortgage loans in Table 1 applying (16), see Table 7.

Table 7 contains the same values as Table 1 except for the new column showing risk-adjusted APRCs. These new measures are much more homogeneous than plain APRCs; their differences are

Figure 6. Spot and 1-year forward rates in the Hungarian Treasury bond market, 14.07.2017.

Note: As the longest maturity of the spot yield curve is around 14.27 years, we simply supposed that the last forward rate (4.86) applies to the later periods.

Source: www.akk.hu

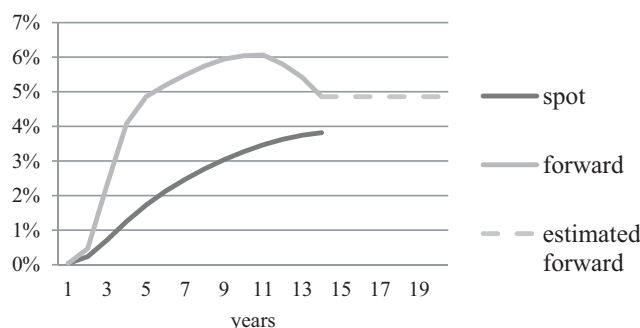


Table 7. Plain versus risk-adjusted APRC in Hungary (20 years, 20 M HUF, 2017.07.16)

Interest rate period (year)	Plain APRC	Risk-adjusted APRC*	Payment per month (HUF)	Borrowing rate (r)	Treasury bond reference yield (y)	Spread ($s = r - y$)
1	2.38%	6.28%	104 289	2.33%	0.09%	2.24%
3	3.72%	6.83%	116 919	3.59%	0.78%	2.81%
5	4.14%	6.12%	121 527	4.03%	1.77%	2.26%
10	5.23%	5.65%	132 760	5.07%	3.08%	1.99%
20	5.90%	5.90%	140 374	5.75%	3.61%	2.14%

*Administration costs are not included as their cash-flows were not available.

due to the differences in spreads, but not to the shape of the reference yield curve anymore. In this example, we get that the 10 and 20-year fixed rate structures have the lowest risk-adjusted APRC; hence these two might be the most favorable for most of the borrowers. Banks seem to earn more and risk more on borrowers choosing shorter interest rate periods. Note that ranking should rely on the risk-adjusted APRC as all other popular measures, like payments per month, borrowing rates, reference yields can be misleading because these are temporary indicators prevailing only at the initiation of the contract.

6. Conclusions

The excessive risk taking of mortgage borrowers increases the systemic risk which has significant adverse spill-over effects for the whole society. Regulators may control these phenomena in many ways. We propose to introduce a new measure to rank credit products which reflects the pure charges of borrowing. We keep the underlying logic of the present APRC formula; however, instead of assuming that uncertain variables (reference yields and FX rates) remain the same over time, we suggest replacing them with suitable forward rates, i.e., with their certainty equivalents (CEQ). In this way, we get the so-called risk-adjusted APRC that can be interpreted similarly to the present plain APRC with the exception that now it really contains all costs of borrowing - even the potential costs of risk hedging. It is a natural idea in finance to convert risks into costs. This conversion is simple as far as the hedging instruments are traded and their prices can be determined, i.e., markets are complete.

Based on the empirical literature of mortgage markets, we can assume that a large part of the borrowers is just minimizing APRC to save the difference in the reference yields which is about 3.5% in Hungary. Such or even more accentuated yield curve patterns can be found in many countries which can be a key factor behind ARM borrowing with extremely short interest rate period.

To quantify the risk of ARM loans, we derive the semi-elasticities of the monthly payment to the borrowing rate and to the reference yield. The first one turns to be equal to the modified duration of a similar but fixed rate loan, while the second one depends on the spread algorithm. If the spread is fixed, then it is the modified duration again, however, in the case of a proportional spread, it is k times the modified duration, where k is the spread multiplier. If a proportional spread is allowed with, say, $k = 1.25$, as, e.g. in Hungary, then the proportional-spread ARM loans comprehend also the hidden risk that payments will increase by 25% more than in the case of the fixed-spread ARM loans. Thus, proportional spreads aggravate the perverse incentives of irresponsible risk-taking, and should not be tolerated by a prudent regulator.

In Hungary, right after the consolidation of the foreign currency mortgage crisis of 2008–2015, a new home lending wave is starting in 2016–2017 where 69% of the borrowers take HUF-

denominated, but adjustable-rate mortgages (ARM), and more than the half of them choose extremely short (1-year or less) interest rate periods.

Performing a scenario analysis, we show that a typical household cannot afford the risk of increasing payments. If the interest rate period is one year and the spread is fixed, then under realistic Scenarios 1, 2, and 3, payments increase by 28%, 49%, and 81%, respectively, which puts the ability-to-pay of the borrowers into danger. If the net income of the borrower does not change, then PTI increases by the same ratio, e.g. if it was initially 50% (according to the present regulation this is the maximum at the beginning of the loan contract), then the new PTI will be 64%, 74.5%, and 90.5%, respectively, which makes the loan impossible to repay for many households.

We also demonstrate that adjustable-rate mortgages are comparable to foreign currency denominated loans in terms of their cash-flow risk and social impact. With ARM loans, the gain in APRC is somewhat lower (3–4% versus 5–6%), but the weight of ARM loans within the total household loan portfolio is larger (73% versus 68%), and the potential increase in payments is approximately the same as experienced during the recent, foreign currency mortgage crisis.

Using this formula and examining past time series of T-bill and CHF/HUF rates, we conclude that in the last two decades in Hungary, households borrowing at a variable rate would have run slightly more cash-flow risk than those borrowing in the Swiss franc.

The virtual advantage of adjustable-rate (or foreign currency) loans would immediately disappear if clients hedged the risk of variable reference yields (or FX rates) in the forward markets and the costs of this hedging were included in the APRC calculation. Note that we do not suggest hedging all interest and FX rate risks in effect, just calculating the costs of hypothetical hedging and to incorporate them into the new version of APRC.

Consequently, the EU-level regulation of the APRC calculation should be reformed to ensure the comparability of loan products, to protect consumers, and to avoid new mortgage crises. This requires a collective thinking of academicians, practitioners, and policymakers, and a careful elaboration of the technical and administrative details.

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