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Estimating the excess of interests paid by consumers when applying an upper rate. The case of Spain

Salvador Cruz Rambaud and Paula Ortega Perals
Departamento de Economía y Empresa, Universidad de Almería, Almería, Spain

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Abstract

Purpose – The framework of this paper is financial mathematics and, more specifically, the control of data fraud and manipulation with their subsequent economic effects, namely, in financial markets. The purpose of this paper is to calculate the global loss or gain, which supposes, for the borrower, a change of the interest rate while the contracted loan is in force or, in another case, the loan has finished.

Design/methodology/approach – The methodology used in this work has been, in the first place, a review of the existing literature on the topic of manipulability and abusiveness of the loan interest rates applied by banks; in the second place, the introduction of a mathematical-financial analysis to calculate the interests paid in excess; and, finally, the compilation of several sentences issued on the application of the so-called mortgage loan reference index (MLRI) to mortgage loans in Spain.

Findings – There are three main contributions in this paper. First, the calculation of the interests paid in excess in the amortization of mortgage loans referenced to an overvalued interest rate. Second, an empirical application shows the amount to be refunded to a Spanish consumer when amortizing his/her mortgage loan referenced to the MLRI instead of the Euro InterBank Offered Rate (EURIBOR). Third, consideration has been made to the effects and the possible solutions to the legal problems arising from this type of contract.

Research limitations/implications – This research is a useful tool capable of implementing the financial calculation needed to find out overpaid interests in mortgage loans and to execute the sentences dealing with this topic. However, a limitation of this study is the lack of enough sentences on mortgage loans referenced to the MLRI to get some additional information about the number of borrowers affected by these legal sentences and the amount refunded by the financial institutions.

Originality/value – To the best of the authors' knowledge, this is the first time that deviations in the payment of interests have been calculated when amortizing a mortgage.

Keywords Mortgage loan reference index, EURIBOR, Mortgage loan, Overvalued interest rate, Repayment method

Paper type Research paper

1. Introduction

The *framework* of this paper is the control of financial operations, more specifically the control of mortgage loans. A financial control is a procedure able to prevent or detect

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accounting errors (such as account reconciliation and double-counting cash deposits) and illegal practices. In the specific case of a mortgage, it is well known that the inputs that determine the amortization of a loan are the duration (term), the interest rate and the repayment method to calculate the periodic payment (see Figure 1). Obviously, the change of any of these inputs involves a variation in the periodic payment, which can suppose a loss or a gain for the borrower. In some cases, a revision of the initially agreed conditions of a loan can detect a mistake in any of its inputs. In this paper, we are interested in determining the consequences of a correction of any input when the loan either is in force or has finished. Specifically, the main *purpose* of this manuscript is to calculate the global loss or gain, which supposes the excess of interests paid by borrowers when amortizing their mortgage loans by using an excessive interest rate.

Recently, Spanish courts have ruled in favor of mortgage borrowers when financial institutions have applied the so-called "Mortgage Loan Reference Index" (MLRI), instead of the Euro InterBank Offered Rate (EURIBOR), in the amortization of their loans. In effect, at the moment of the issued sentences, about one million mortgages (between 10% and 13% of all mortgages) were referenced to the so-called MLRI. It has been estimated that the borrowers of these loans have paid a high amount of additional interests with respect to the same mortgages referenced to the EURIBOR (about 2% of the total interests). Undoubtedly, this fact can have serious implications on the demand of consumers. Moreover, the relevance

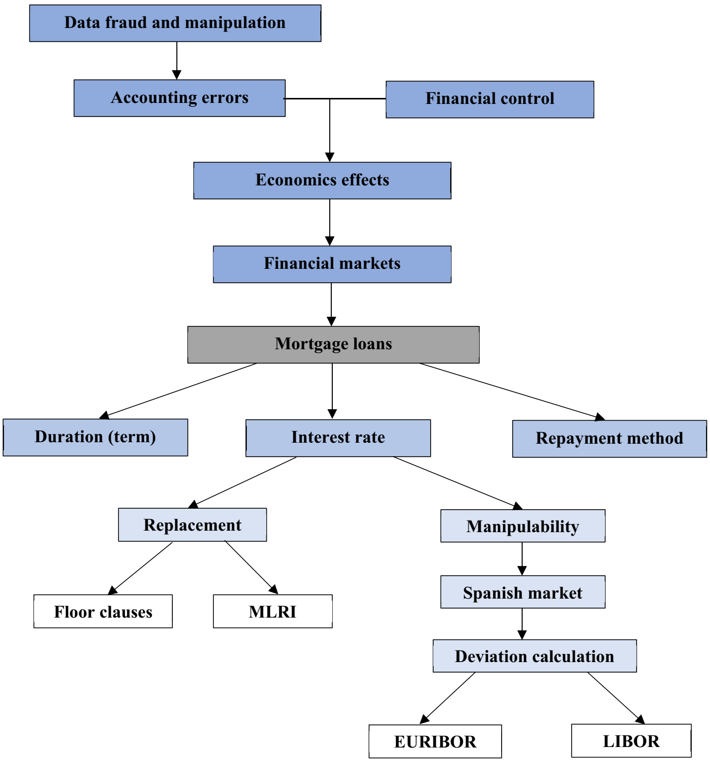

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Figure 1.
Control of mortgage loans

of this topic is *justified* by the huge amount improperly or illegally charged by financial institutions when there is a mistake or abusiveness in the application of some conditions (inputs) in standard loans marketed on a large scale.

The *research question* of this work is therefore: What is the amount that the borrower has paid in excess? The difficulty of this issue lies in the wide variety of repayment methods that require a general solution to the problem. The main *contribution* of this paper is the method proposed to solve this problem, which converts this research into a relevant tool to be applied when executing sentences on this topic.

The *methodology* used in this work has been, in the first place, a review of the existing literature on the topic of controlling the loan interest rates applied by banks; in the second place, the introduction of closed formulae to calculate the amount paid in excess by the borrower; and, finally, the compilation of several sentences issued on the application of certain reference indices to mortgage loans. The existing literature has used several approximations to calculate the excess of payments. However, a general financial approach is needed because a high variety of repayment methods have been implemented in the banking mortgage offer. Because of this need, we have approached this topic by exclusively using financial tools.

The *main finding* of this paper is the derivation of general formulae that can be applied to the amortization of all mortgage contacts. The findings of this paper have important consequences on the issue of mortgage bonds, whose payment obviously depends on the punctual and accurate receipt of the due interests generated by the involved mortgages. Thus, this topic is very interesting because less perceived interests can give rise to small bank crises. Moreover, a good control system must be capable of offering effective tools to reach a fair situation for consumers. On the one hand, there is no doubt about the noteworthy social *implications* derived from the application of legal sentences committing financial institutions to reimburse the interests paid in excess by their clients. On the other hand, the financial institutions must pay attention to the legal coefficients involving their leverage, which can be seriously affected by these reimbursements.

After this introduction, the *structure* of this paper remains as follows. Section 2 presents a review of the literature on this topic. Section 3 provides the financial point of view, trying to determine the expressions that quantify how consumers are affected by a change (manipulation or replacement) in the initially agreed interest rate. A special consideration will be made to different loan amortization methods, with a detailed explanation of involved calculations. Section 3 discusses, from a legal point of view, the possible application of EURIBOR instead of other interest rates in the amortization of mortgage loans. Section 4 makes a special consideration of the MLRI when used to replace the EURIBOR in mortgages, and later, a numerical case is presented in Section 5 to quantify the repercussion of this replacement. Finally, Section 6 summarizes and concludes.

2. Literature review

Currently, the financial system is the result of several changes that have taken place in recent years. One of these changes has been the implementation of the EURIBOR and London InterBank Offered Rate (LIBOR) as the reference for determining the interest rate to be applied to mortgages. In effect, the EURIBOR is a variable index created by the European Central Bank (ECB) as the average of the interest rates applied to the loans granted among the major European banks. It was created to be implemented in 1999 (the year in which the ECB began to develop its functions with the entry of the euro), with several maturities that can be applied in the financial markets. At the beginning, this interest rate reached high figures; later, it reached its minimum value in January 2021 (−0.505%), and nowadays, it takes an average value of 3.337% (January 2023). The formation mechanism of the EURIBOR is simple, as it is determined by the law of supply and demand. This makes the EURIBOR an unstable index in such a way that it varies according to the economic circumstances, so that it can be in favor or against consumers, depending on the inflation rate or the growth of a country's economy at a given moment. It should be noted that, in most cases, the EURIBOR is not directly the interest rate to be applied to mortgage loans because this rate is the result of adding up a fixed differential to the reference index. Moreover, in Spain, it is a variable interest rate, which is known mainly due to its application in mortgage loans. However, it is not only used for these contracts but also for a large number of types of products, such as swaps or futures.

In recent years, both the EURIBOR and LIBOR have been questioned. In the case of the LIBOR, this has been due to its manipulation (see Figure 1) by banks since 2008, trying to set a lower interest rate to make it more attractive, thus positioning banks in a more solvent position *vis-à-vis* borrowers (Herrera *et al.*, 2022; Muchimba, 2022; Eisl *et al.*, 2017; Orlando *et al.*, 2020). But the reality has been that LIBOR has fluctuated more and has been higher than other equivalent interest rates (Braml, 2015; Herrera *et al.*, 2020). In effect, this interest rate began to be marketed under the assumption of providing greater security than other interest rates (Fouquau and Spesier, 2015). Consequently, it has been widely used in the United Kingdom and the USA, where it has led to important financial scandals, such as in June 2012 when Barclays agreed to pay a fine imposed by the Commodity Futures Trading Commission of £290m (Fouquau and Spesier, 2015; Herrera *et al.*, 2022).

Then, there is a need to look for a way to solve the interest rate calculation or to seek solutions to avoid further manipulations (Bajg and Winters, 2021). A part of the existing literature on this topic attempts to solve the asymmetry of information in the markets, which may induce this type of behavior (Nguyen and Le, 2023). Thus, in Coulter *et al.* (2018), an attempt is made to minimize manipulation through a mathematical-financial model. On the other hand, Muchimba (2022) and Bajg and Winters (2022) propose the secured overnight financial rate as an alternative to the LIBOR in the case of proven bank manipulation. Another study on LIBOR replacement is based on a process and a set of requirements that must be met by the method by which the LIBOR is replaced (Evans and Abrantes-Metz, 2012). Courts have offered different solutions depending on the specific case of manipulation and abusiveness exercised by banks when applying interest rates in different contracts (Coulter *et al.*, 2018; Schäfer and Wulf, 2022). One of the solutions is to replace the contracted interest rate with another one with similar conditions (as seen in Figure 1), although this coincidence is rarely possible (Kalinin and Peer, 2021). For example, the EURIBOR can be used as a substitute for the LIBOR, which, as formerly indicated, can be manipulated. This is a possibility similar to the one presented in the next section of this paper.

With respect to the EURIBOR, this rate can be manipulated according to market circumstances and according to the convenience of banks to demonstrate their solvency at any given time (Rodríguez-López *et al.*, 2021). Moreover, the EURIBOR is mostly used for mortgage loan contracts and, therefore, affects consumers in this kind of loans.

As formerly indicated, the main objective of this paper is to calculate the global loss or gain, which supposes, for the borrower, a change of the interest rate while the contracted loan is in force or, alternatively, once the paper has finished. In this context, differently from manipulation of interest rates, another issue related to the EURIBOR is the existence of certain clauses in mortgage loans by which the initially applied interest rate (EURIBOR plus a differential) is replaced by a higher interest rate. In Spain, this *replacement* can be made in two ways:

(1) The initial interest rate is replaced by a greater fixed interest rate. This occurs when the EURIBOR falls below a given value, which the financial institution considers as the minimum profitability rate. The clauses allowing this kind of behavior are called “floor clauses”; and

(2) The initial interest rate is replaced by a greater variable interest rate (usually, plus a differential). This occurs when certain financial institutions apply a reference interest rate whose formation is less transparent than EURIBOR. This is the case of the so-called mortgage loan reference index (hereinafter, MLRI. In Spanish, IRPH: “Índice de Referencia de los Préstamos Hipotecarios”).

3. Calculation of the interests to be reimbursed when correcting the interest rate applied in a loan

3.1 By using the French repayment method

In this paragraph, i'_s ($s = 1, 2, \ldots, n$) is going to denote the successive interest rates applied by a financial institution, instead of i_s ($i'_s > i_s$), to a loan of principal C_0. Obviously, if f denotes the number of periods in which i'_s have been applied instead of i_s ($f \leq n$, because the interest rate could have been corrected before the end of the loan), the interests to be reimbursed at time f to the borrower must be:

$$\begin{aligned} M &:= \sum_{s=1}^{f-1} (I'_s - I_s) \prod_{j=s+1}^{f} \left(1 + i_j^l\right) + \left(I'_f - I_f\right) \\ &= \sum_{s=1}^{f} (C'_{s-1} i'_s - C_{s-1} i_s) \prod_{j=s+1}^{f} \left(1 + i_j^l\right) + \left(C'_f i'_f - C_f i_f\right) \end{aligned} \quad (1)$$

where

- I'_s (resp. I_s) represents the interests generated during the period s by applying i'_s (resp. i_s);
- C'_s (resp. C_s) denotes the balance of the loan at the end of period $s-1$ by applying i'_s (resp. i_s); and
- i_j^l is the legal interest rate to be applied during the period j ($j = s+1, \ldots, f-1$).

The following general theorem is going to derive a novel formula for an easy computation of the balances involved in the operation.

Theorem 1. The balance C_s of a loan at time s by applying the successive interest rates i_s ($s = 1, 2, \ldots, n$) satisfies the following expression:

$$C_s = C_0 \prod_{k=1}^{s} \frac{a_{\overline{n-k|}\, i_k}}{a_{\overline{n-k+1|}\, i_k}} = C_0 \prod_{k=1}^{s} \frac{1 - (1 + i_k)^{-(n-k)}}{1 - (1 + i_k)^{-(n-k+1)}}. \quad (2)$$

Proof. Assume that the bank applies the interest rate i_1 when the outstanding principal of the loan is C_0. By applying the so-called prospective method, the balance at the end of the first period has the following expression:

$$C_1 = a_1 \cdot a_{\overline{n-1|}\, i_1} = \frac{C_0}{a_{\overline{n|}\, i_1}} a_{\overline{n-1|}\, i_1} = C_0 \frac{1 - (1 + i_1)^{-(n-1)}}{1 - (1 + i_1)^{-n}}, \quad (3)$$

where a_1 is the constant payment corresponding to the first period and $a_{\overline{n|}\,i}$ the present value of a unitary, temporal income of n terms, post-payable and valued at a rate i.

Next, we are going to make a similar reasoning for the next period, in which the bank applies an interest rate i_2. Analogously, the balance at the end of the second period, by applying the prospective method, shows the following expression:

$$C_2 = a_2 \cdot a_{\overline{n-2|}\,i_2} = \frac{C_1}{a_{\overline{n-1|}\,i_2}} a_{\overline{n-2|}\,i_2} = C_1 \frac{1-(1+i_2)^{-(n-2)}}{1-(1+i_2)^{-(n-1)}}, \tag{4}$$

where a_2 is the constant payment corresponding to the second period. Now, by substituting in the above expression, the one deduced for C_1 according to C_0, one would have:

$$C_2 = C_0 \frac{a_{\overline{n-1|}\,i_1}}{a_{\overline{n|}\,i_1}} \frac{a_{\overline{n-2|}\,i_2}}{a_{\overline{n-1|}\,i_2}} = C_0 \frac{1-(1+i_1)^{-(n-1)}}{1-(1+i_1)^{-n}} \frac{1-(1+i_2)^{-(n-2)}}{1-(1+i_2)^{-(n-1)}}. \tag{5}$$

In general, it could be shown by recurrence that the balance at the end of period s, by applying the prospective method, exhibits the following expression:

$$C_s = C_0 \prod_{k=1}^{s} \frac{a_{\overline{n-k|}\,i_k}}{a_{\overline{n-k+1|}\,i_k}} = C_0 \prod_{k=1}^{s} \frac{1-(1+i_k)^{-(n-k)}}{1-(1+i_k)^{-(n-k+1)}}, \tag{6}$$

which concludes the proof of this theorem.

Obviously, the same expression applies when the interest rates are $i_s^{'}$ ($s = 1, 2, \ldots, n$):

$$C_s^{'} = C_0 \prod_{k=1}^{s} \frac{a_{\overline{n-k|}\,i_k^{'}}}{a_{\overline{n-k+1|}\,i_k^{'}}} = C_0 \prod_{k=1}^{s} \frac{1-\left(1+i_k^{'}\right)^{-(n-k)}}{1-(1+i_k^{'})^{-(n-k+1)}}. \tag{7}$$

Remark 1. In the particular case in which all the interest rates, used in this study, coincide (i.e., $i_1 = i_2 = \cdots = i_k = \cdots = i_s = i$), one would have:

$$C_s = C_0 \prod_{k=1}^{s} \frac{a_{\overline{n-k|}\,i}}{a_{\overline{n-k+1|}\,i}} = \frac{C_0}{a_{\overline{n|}\,i}} a_{\overline{n-k|}\,i} = a_1 \cdot a_{\overline{n-k|}\,i}, \tag{8}$$

which is the well-known formula of the balance by applying the prospective method.

Remark 2. We are going to analyze the behavior (increase or decrease) of each ratio in the balances derived by Theorem 1. To do this, observe that each of them can be written as follows:

$$\frac{1-(1+i_k)^{-(n-k)}}{1-(1+i_k)^{-(n-k+1)}} = 1 + i_k \left[1 - \frac{1}{1-(1+i_k)^{-(n-k+1)}}\right]. \tag{9}$$

Consequently, each ratio is increasing with the interest rate, so that $C_s^{'} > C_s$, i.e. as expected the outstanding principal by applying $i^{'}_s$ is higher. This is logical because, as interest rates are higher, a little part of the payment is used to repay the loan principal. Therefore:

$$C'_{s-1}i'_s > C_{s-1}i_s, \tag{10}$$

from where:

$$I'_s > I_s. \tag{11}$$

3.2 An alternative formula for reimbursement

The following theorem is going to derive a novel formula for the difference of the periodic payments involved in the operation.

Theorem 2. If a'_s (resp. a_s) denotes the periodic payment of the loan at time s by applying i'_s (resp. i_s), then:

$$a'_s - a_s = C_0\left(\frac{1}{a_{\overline{n-s+1|}\,i'_s}}\prod_{k=1}^{s-1}\frac{a_{\overline{n-k|}\,i'_k}}{a_{\overline{n-k+1|}\,i'_k}} - \frac{1}{a_{\overline{n-s+1|}\,i_s}}\prod_{k=1}^{s-1}\frac{a_{\overline{n-k|}\,i_k}}{a_{\overline{n-k+1|}\,i_k}}\right). \tag{12}$$

Proof. In effect, assume that the bank starts to apply the interest rate i'_1 instead of i_1, being $i'_1 > i_1$ when the outstanding principal of the loan is C_0. Therefore, the payments corresponding to both interest rates are $a'_1 = \frac{C_0}{a_{\overline{n|}\,i'_1}}$ and $a_1 = \frac{C_0}{a_{\overline{n|}\,i_1}}$, respectively, and the total amount overpaid during the first period shall be:

$$a'_1 - a_1 = C_0\left(\frac{1}{a_{\overline{n|}\,i'_1}} - \frac{1}{a_{\overline{n|}\,i_1}}\right) > 0. \tag{13}$$

Indeed, it should be taken into account that, being $i'_1 > i_1$, as the function $a_{\overline{n|}\,i}$ is strictly decreasing with respect to i, the inequality $a_{\overline{n|}\,i'_1} < a_{\overline{n|}\,i_1}$ holds, and so $\frac{1}{a_{\overline{n|}\,i'_1}} > \frac{1}{a_{\overline{n|}\,i_1}}$.

In the second period, the bank applies an interest rate i'_2 instead of i_2, being $i'_2 \geq i_2$. Therefore, the payments corresponding to both interest rates are $a'_2 = \frac{C'_1}{a_{\overline{n-1|}\,i'_2}}$ and $a_2 = \frac{C_1}{a_{\overline{n-1|}\,i_2}}$, respectively, and the total amount overpaid during that period shall be:

$$a'_2 - a_2 = \frac{C'_1}{a_{\overline{n-1|}\,i'_2}} - \frac{C_1}{a_{\overline{n-1|}\,i_2}} > 0. \tag{14}$$

Observe that, although i'_2 could be equal to i_2 (e.g. in the case where, during the second period, the interest rate has been corrected), the difference $a'_2 - a_2$ is still positive because, being $i'_1 > i_1$, as the function $s_{\overline{n|}\,i}$ is strictly increasing with respect to i, the inequality $a_{\overline{n|}\,i'_1} < a_{\overline{n|}\,i_1}$ holds, and so $A'_1 = \frac{C_0}{s_{\overline{n|}\,i'_1}} < \frac{C_0}{s_{\overline{n|}\,i_1}} = A_1$. Consequently, $C'_1 = C_0 - A'_1 > C_0 - A_1 = C_1$. Moreover, it should be observed that, as in the first period, one has $a_{\overline{n-1|}\,i'_2} < a_{\overline{n-1|}\,i_2}$. Now, by applying the prospective method, the balance at the end of the first period can be calculated by expression (3). Moreover, a similar expression could be deduced for C'_1, according to i'_1. Consequently:

$$a'_2 - a_2 = C_0\left(\frac{a_{\overline{n-1|}\,i'_1}}{a_{\overline{n|}\,i'_1}a_{\overline{n-1|}\,i'_2}} - \frac{a_{\overline{n-1|}\,i_1}}{a_{\overline{n|}\,i_1}a_{\overline{n-1|}\,i_2}}\right). \tag{15}$$

Now, let us make the reasoning for the third period in which the bank applies an interest rate i'_3 instead of i_3, being $i'_3 \geq i_3$. Therefore, the payments corresponding to both interest rates are $a'_3 = \frac{C'_2}{a_{\overline{n-2|}\,i'_1}}$ and $a_3 = \frac{C_2}{a_{\overline{n-2|}\,i_3}}$, respectively, and the total amount overpaid during that period shall be:

$$a'_3 - a_3 = \frac{C'_2}{a_{\overline{n-2|}\,i'_3}} - \frac{C_2}{a_{\overline{n-2|}\,i_3}} > 0. \tag{16}$$

Observe again that, although i'_3 could be equal to i_3 (e.g. in the case where, during the third period, the interest rate has been corrected), the difference $a'_3 - a_3$ is positive because $C'_2 > C_2$ and $a_{\overline{n-2|}\,i'_3} < a_{\overline{n-2|}\,i_3}$. In addition, by applying the prospective method, the balance at the end of the second period follows expression (4) from where expression (5) could be obtained.

A similar expression could be deduced for C'_2, according to i'_2. Consequently:

$$a'_3 - a_3 = C_0\left(\frac{a_{\overline{n-1|}\,i'_1}a_{\overline{n-2|}\,i'_2}}{a_{\overline{n|}\,i'_1}a_{\overline{n-1|}\,i'_2}a_{\overline{n-2|}\,i'_3}} - \frac{a_{\overline{n-1|}\,i_1}a_{\overline{n-2|}\,i_2}}{a_{\overline{n|}\,i_1}a_{\overline{n-1|}\,i_2}a_{\overline{n-2|}\,i_3}}\right). \tag{17}$$

In general, by applying the prospective method, the balance at the end of the period s follows expressions (6) and (7) and, therefore:

$$a'_s - a_s = C_0\left(\frac{1}{a_{\overline{n-s+1|}\,i'_s}}\prod_{k=1}^{s-1}\frac{a_{\overline{n-k|}\,i'_k}}{a_{\overline{n-k+1|}\,i'_k}} - \frac{1}{a_{\overline{n-s+1|}\,i_s}}\prod_{k=1}^{s-1}\frac{a_{\overline{n-k|}\,i_k}}{a_{\overline{n-k+1|}\,i_k}}\right), \tag{18}$$

which concludes the proof of this theorem.

3.3 Comparing both methods

Section 3.1 has been devoted to the calculation of the differences of interests, $I'_s - I_s$, while Section 3.2 has displayed an expression for determining the differences of periodic payments, $a'_s - a_s$. Observe that the latter difference can be decomposed as follows:

$$a'_s - a_s = \left(I'_s - I_s\right) + \left(A'_s - A_s\right). \tag{19}$$

As formerly shown in Section 3.1, the first parenthesis, $I'_s - I_s$, is positive, while the second, $A'_s - A_s$, is negative. Therefore, this equation can be interpreted in the following way: the amount to be repaid by the borrower is lower because the repayment of the loan would have to be continued as if the repayment installments had been A_s, that is to say, by continuing the repayment from $\min\left\{C_f, C'_f\right\}$. Now, if we write:

$$I'_s - I_s = \left(a'_s - a_s\right) + \left(A_s - A'_s\right), \tag{20}$$

the overpaid interests would include both the overpaid payments and the overpaid principal, so that the repayment of the loan would have to be continued as if the repaid principal had been A'_s, that is to say, by the repayment continuing from $\max\left\{C_f, C'_f\right\}$.

In other words, taking into account that the borrower has paid a'_s, two situations are possible:

(1) The bank reimburses the difference $a'_s - a_s$, in whose case it will have actually paid $a'_s - (a'_s - a_s) = a_s = I_s + A_s$, which corresponds to the payment of the correct interests and higher repaid principal ($A_s > A'_s$), thus continuing the repayment of the outstanding principal starting from the smallest amount between C_f and C'_f; and

(2) The financial institution reimburses the difference $I'_s - I_s$, in whose case it will have actually paid $a'_s - (I'_s - I_s) = I_s + A'_s$, which corresponds to the payment of the correct interests and lower repaid principal ($A'_s < A_s$), thus continuing the repayment of the outstanding principal starting from the higher amount between C_f and C'_f.

3.4 By using the constant repaid principal method

In this particular case, the following statement can be shown.

Theorem 3. The arithmetic sum of interests (without considering legal interests) to be reimbursed at time f to the borrower is:

$$M := C_0 \sum_{s=1}^{f} \left(1 - \frac{s-1}{n}\right)\left(i'_s - i_s\right). \tag{21}$$

Proof. Assume that the bank starts to apply the interest rate i'_1 instead of i_1, being $i'_1 > i_1$ when the outstanding principal of the loan is C_0. Therefore, the interests corresponding to both interest rates are $I'_1 = C_0 i'_1$ and $I_1 = C_0 i_1$, respectively, and the interests paid in excess, during the first period, shall be:

$$I'_1 - I_1 = C_0\left(i'_1 - i_1\right) > 0. \tag{22}$$

In the second period, the bank applies an interest rate i'_2 instead of i_2, being $i'_2 \geq i_2$. Therefore, the interests corresponding to both interest rates are $I'_2 = C_1 i'_2$ and $I_2 = C_1 i_2$, respectively, and the interests paid in excess, during that period, shall be:

$$I'_2 - I_2 = C_1 i'_2 - C_1 i_2 = C_1\left(i'_2 - i_2\right) \geq 0. \tag{23}$$

Observe that, in this repayment method, the outstanding principal is independent of the applied interest rate. Moreover, by applying the prospective method, the balance (after the corresponding payment, as usual in loans) at the end of the first period has the following expression:

$$C_1 = C_0 - A = C_0 - \frac{C_0}{n} = C_0\left(1 - \frac{1}{n}\right). \tag{24}$$

Now, let us make the reasoning for the third period, in which the bank applies an interest rate i'_3 instead of i_3, being $i'_3 \geq i_3$. Therefore, the interests corresponding to both interest rates are $I'_3 = C_2 i'_3$ and $I_3 = C_2 i_3$, respectively, and the interests paid in excess, during that period, shall be:

$$I'_3 - I_3 = C_2 i'_3 - C_2 i_3 = C_2\left(i'_3 - i_3\right) \geq 0. \tag{25}$$

Observe again that, in this repayment method, the outstanding principal is independent of the applied interest rate. Now, by applying the prospective method, the balance at the end of the second period shows the following expression:

$$C_2 = C_1 - A = C_0\left(1 - \frac{1}{n}\right) - \frac{C_0}{n} = C_0\left(1 - \frac{2}{n}\right). \tag{26}$$

In general, it could be shown by recurrence that the balance at the end of period s, by applying the prospective method, exhibits the following expression:

$$C_s = C_0\left(1 - \frac{s}{n}\right). \tag{27}$$

Thus, if f denotes the number of periods during which an upper interest rate has been applied ($f \leq n$, because the interest rate could have been corrected before the end of the loan), the arithmetic sum interests to be paid back to the borrower amounts:

$$M := \sum_{s=1}^{f}\left(I'_s - I_s\right) = \sum_{s=1}^{f}\left(C'_{s-1}i'_s - C_{s-1}i_s\right) = C_0\sum_{s=1}^{f}\left(1 - \frac{s-1}{n}\right)\left(i'_s - i_s\right), \tag{28}$$

where no legal interests have been included.

3.5 By using the American repayment method

In this particular case, the following statement can be shown.

Theorem 4. The arithmetic sum of interests (without considering legal interests) to be reimbursed at time f to the borrower is:

$$M := C_0\sum_{s=1}^{f}\left(i'_s - i_s\right). \tag{29}$$

Proof. Assume that the bank starts to apply the interest rate i'_1 instead of i_1, being $i'_1 > i_1$ when the outstanding principal of the loan is C_0. Therefore, the interests corresponding to both interest rates are $I'_1 = C_0 i'_1$ and $I_1 = C_0 i_1$, respectively, and the interests paid in excess, during the first period, are given by expression (22). In the second period, the outstanding principal remains C_0, and the bank applies an interest rate i'_2 instead of i_2, being $i'_2 \geq i_2$. Therefore, the interests corresponding to both interest rates are now $I'_2 = C_0 i'_2$ and $I_2 = C_0 i_2$, respectively, and the interests paid in excess, during that period, shall be:

$$I'_2 - I_2 = C_0\left(i'_2 - i_2\right) \geq 0. \tag{30}$$

Now, we will make the reasoning for the third period, in which the outstanding principal is still C_0 and the bank applies an interest rate i'_3 instead of i_3, being $i'_3 \geq i_3$. Therefore, the interests corresponding to both interest rates are $I'_3 = C_0 i'_3$ and $I_3 = C_0 i_3$, respectively, and the interests paid in excess, during that period, shall be:

$$I'_3 - I_3 = C_0\left(i'_3 - i_3\right) \geq 0. \tag{31}$$

Therefore, if f is the number of periods during which an upper interest rate has been applied ($f \leq n$, because the interest rate could have been corrected before the end of the loan), the interests to be paid back to the borrower amounts:

$$M := \sum_{s=1}^{f} \left(I'_s - I_s \right) = C_0 \sum_{s=1}^{f} \left(i'_s - i_s \right), \tag{32}$$

where no legal interests have been included.

Observe that, in this section of the paper, we have not included loans whose payments are variable in arithmetic and geometric progression because they are hardly used by financial institutions. Part of the basis used in this section can be found in Serret and Trello (2013).

4. A special mention to the mortgage loan reference index

4.1 Introduction

In 1990, the so-called mortgage loan reference index (hereinafter, MLRI. In Spanish: "Índice de Referencia de los Préstamos Hipotecarios") was created by the Circular 8/1990 (which was subsequently modified by the Circular 5/1994 of July 22, 1994, to credit institutions, which partially modified the Circular 8/1990, on transparency of operations and customer protection). Logically, the introduction of this interest rate in the Spanish financial market supposed a new source of uncertainty different from the other existing risks (González Arroyo, 2017).

Similarly to LIBOR and EURIBOR, the MLRI began to be applied more frequently after the financial crisis of 2008 (Coulter *et al.*, 2018; Pinter and Boissel, 2016), when interest rates were lower (Killins *et al.*, 2020). However, these indices started to be questioned in the following years as they were inserted in nontransparent contracts or their calculation could be manipulated by banks. More and more problems were appearing in the financial market as most consumers signed their contracts of mortgage loans without a complete understanding of their content, and financial institutions took advantage of the new interest rates derived from the supply and demand in loan markets. Specifically, it has been estimated that, in a mortgage of €250,000 contracted in 2010, borrowers have paid €25,000 more in concept of interests [1]. In addition, it has been estimated that a total of €17,000m more have been paid with the application of the MLRI instead of EURIBOR [2]. Moreover, there are around 300,000 loans in force in 2020 (approximately 20% of the mortgages signed in Spain [3]), from which consumers could recover an average of €20,000 in concept of excessive interests [4]. According to the Goldman Sachs report, if the Court of Justice of the European Union (CJEU) rules that the MLRI is excessive, banks would face losses between €7,000 and €44,000m, with Caixabank and Santander being placed on top of the list of financial institutions most affected [5]. As it can be seen, the damages caused by this index are valued in millions of euros, and millions of people affected, so it is necessary to study the situation in depth. Therefore, one of the objectives of this study is to review the existing literature on the problems caused by these interest rates in the market since the 2008 crisis, highlighting the problems of manipulation and abusiveness they have presented by including an empirical case extracted from the Spanish market.

4.2 Defining the mortgage loan reference index

The MLRI is an interest rate defined as the arithmetic average of the interest rates in the market of mortgage loans over three years (Circular 5/1994 of July 22, 1994). In the beginning, three interest rates were created: the so-called "MLRI for Saving Banks", "MLRI for Banks" and "MLRI for all financial entities". According to the second additional provision of the Circular 2/1994 of March 30, 1994, the definition and method of calculation of these reference rates have been respectively detailed in the Annex VIII in the following way:

- average rate of the mortgage loans over three years, granted by savings banks, for the purchase of free housing;
- average rate of the mortgage loans for more than three years, granted by banks, for the purchase of free housing; and
- average rate of mortgage loans over three years, granted by credit institutions as a whole, for the purchase of free housing.

As indicated by Amat Llombart (2018), the Bank of Spain will notify these indices appropriately, and, in any case, they shall be published monthly in its official gazette ("Boletín Oficial del Estado"). However, over the years, the financial system has been reformed, and all types of MLRI are brought together in the so-called "MLRI for all financial entities," which nowadays is the only one in force in the financial market of mortgage loans.

The MLRI presents a series of characteristics (González Arroyo, 2017) that make it different from other interest rates in force in the financial market and that are necessary to be mentioned in this paper to understand the main problem of the interests paid in excess when amortizing a mortgage loan contracted with the MLRI. First, it is necessary to make reference to the variability of this interest rate, as it fluctuates according to certain changes in the market, not always at the same percentages. Because of this characteristic and despite being a variable rate, it is stable, which means that changes exogenous to the market do not cause a variation in this rate. For example, the European Union regulation on the stabilization of interest rates around a certain percentage did not directly affect this specific index, which, depending on each particular case, may be favorable or not to the dynamic of the repayment of a specific loan. In fact, nowadays, the MLRI is well above the average of other less stable indexes, such as the EURIBOR. Second, we must highlight the complexity of its calculation. As the final percentage to be paid as interest rate is built by adding up all commissions and expenses included in the contract to a variable base interest, it is difficult to understand, for an average borrower, the way of calculation of this rate and why it is higher than other interest rates. Third, it is necessary to refer to the supervision process that this index is subjected to. In effect, since its creation by the Bank of Spain, this institution is in charge of its revision and monthly publication to keep an adequate control over it (Ballester Casanella, 2018).

To conclude this point, it is necessary to mention the rounding operation (see Gil Luezas and Gil Peláez, 1987; Valls Martínez and Cruz Rambaud, 2012). This concept makes the MLRI an even more problematic interest rate. The upward rounding mechanism consists in the following approximation process: The Bank of Spain publishes the monthly interest rates in force in the financial market of mortgage loans, as formerly mentioned. When a financial institution applies the MLRI to a specific loan contract, it has the option of choosing between the quartiles of that interest rate. In this way, a quartile is the result of dividing half a percentage point by four. So, the interest rate can be divided into four quartiles, with the highest option being the most likely. For example, if a contract is benchmarked at 2.51%, a rate of either 2.500% or 2.525% could be applied, the second option being more likely, which, obviously, is a detriment to the borrower.

4.3 Legal problems derived from the application of the mortgage loan reference index

As indicated in Subsection 4.1, the MLRI has not been the only index that has affected the loans (whether mortgage or not) of millions of consumers (Rouwendal and Petrat, 2022).

Consequently, the European Union and, specifically, Spain were forced to enact some *ad hoc* laws with the aim to defend the interests of consumers against professionals (Law 7/1998, April 13, on general contracting conditions). Therefore, terms such as abusiveness, lack of transparency in financial contracts and the so-called "general contract clauses" began to appear (Cruz Rambaud and Cruz Vargas, 2021) and a set of case-law and sentences started to be applied to solve the problems arisen with these clauses, such as the Sentence no. 669/2017, issued by the Supreme Court (Civil Chamber, Plenary Section) on December 14, 2017, which represented an important step forward to interpret the lack of transparency in financial contracts, or the Sentence of the CJEU (Fourth Chamber), March 3, 2020, and the Sentence of the Court of CJEU (Grand Chamber), July 16, 2020, which, for the first time, interpreted the legal norm in favor of consumers and led numerous Spanish courts to interpret European regulations in a new way.

More specifically, most courts have recommended that clauses containing the application of the MLRI are completely incompatible with the rest of conditions and, consequently, decided that they will not be applicable to the remaining loan duration and, therefore, that the rate will no longer be applied. In these cases, it is likely the existence of another clause that regulates a subsidiary interest rate, and for this reason, the MLRI can be declared null or void (Ortega Perals, 2021). Moreover, courts may understand that the contract can remain in force without the application of any interest rate, as it is very detrimental to the lender (Provincial Court of Toledo, 2nd Section, sentence no. 52/2020). It can also be the case that the specific clause is replaced by another one containing a more beneficial interest rate for the borrower with the corresponding refund of the excessive interests paid in previous years.

Thus, this article presents one of the main effects derived from the amortization of mortgage loans agreed with application of the MLRI, namely the excess of interests paid by the borrower when applying the so-called MLRI to the repayment of the contracted mortgage loan, to later show an example of the manipulation and abusiveness of the interest rates applied after 2008. Moreover, a comparison with the EURIBOR (Cruz Rambaud and Del Pino Álvarez, 2019) shows that consumers would benefit when applying this interest rate instead of MLRI. More specifically, if the interest rate of the contract is replaced by the EURIBOR, we are interested in determining all the amounts paid in excess by consumers, which should be refunded by the lender institution (Cruz Rambaud and Valls Martínez, 2014). In this way, this article is going to mathematically develop a proposal of solution by presenting the calculations leading to the amount paid in excess by the borrower when his/her mortgage loan contract includes the MLRI instead of other interest rates (in particular, EURIBOR) (Sánchez Lería and Vázquez-Pastor Jiménez, 2018).

On the one hand, Achón Bruñén (2017) explains that, although the excess of interests paid by consumers in this type of contract (in this case, due to the application of floor clauses) have not been reimbursed by the financial entities based on the principle of legal certainty, many courts have finally ordered the restitution of these amounts because of the application of an interest rate whose clause has been declared as abusive. On the other hand, in some sentences, it has been understood that consumers should be reimbursed for the amounts paid in excess during the years of the contract in which the MLRI was applied (Rios Solis *et al.*, 2017). Some of these sentences were issued by courts such as the Provincial Court of Álava (1st Section), sentence no. 349/2020, May 14, AC 2020. In this case, it was clearly specified that the financial institution must reimburse the interests paid in excess due to the application of the MLRI instead of the EURIBOR from the beginning of the mortgage loan. Moreover, the Provincial Court of Girona, sentence no. 5/2018, January 11, ruled on a similar case, but this time, instead of comparing the MLRI with the EURIBOR, it considered that there was also an excess of interests paid due to the application of the so-called MLRI for savings banks instead of the legally applicable interest rate (MLRI for all financial entities). Once again, the financial institution must reimburse the excess of interests paid by the borrower. In another sentence (no. 66/2015, March 16, Provincial Court no. 7 of Barcelona), the same reasoning was used when indicating that the application of the MLRI is more detrimental for consumers than the EURIBOR and that, therefore, the interests already paid until the date of the sentence must be refunded. As observed in Shaw *et al.* (2016), the trend presented in the sentences issued by the courts of first instance tends toward the refund of interests, in the case that a more advantageous situation could be reached when applying another interest rate.

With respect to the decision of the courts of last resort, we have to point out the following remarks. First, the sentence of November 12, 2020, of the Supreme (Civil) Court ratified the sentence of first instance, which obliges the bank to reimburse the interests charged in excess when applying the MLRI. Starting from this sentence, in another line of jurisprudence, the sentence of November 6, 2020, the Supreme Court issued that the interests paid in excess must be returned and that, from that date onwards, the EURIBOR (which is more advantageous for the consumer) will begin to be applied.

To conclude this section, it is important to point out that, in most cases, the interests to be reimbursed are calculated by applying the EURIBOR in force after declaring null and void the contract clause containing the MLRI. However, another solution could be appropriate. To facilitate comparison with the EURIBOR, Pertíñez Vílchez (2017) states that it is useful to specify the equivalent annual rate (EAR) of the operation so that, by comparing the values of both EARs (the variable margins that the interest rate included), the real interest rates of the operation would be compared.

4.4 An empirical application to a real case in the Spanish market

The basic information of the loan to be analyzed has been presented in Table 1.

In this Section, the work has consisted of replacing the MLRI with the EURIBOR plus a spread of 1% to the amortization of the mortgage loan, initially referenced to the MLRI. Observe that, except for some specific moments, the MLRI was always above the EURIBOR, showing an average difference of 1.55 points during the contracted period, with a maximum of 2.79 points in September 2009. For this purpose, we have calculated the difference between the total interests paid by applying the "MLRI over three years for all financial entities" (Table 2) and the total interests by applying the EURIBOR plus a spread of 1% (Table 3). Moreover, this amount should be increased by applying the legal interest rates (Tables 4 and 5). To do this, we have started from the outstanding principal on July 7, 2000 (€150,000.00), which is the moment from which the "MLRI over three years for all financial entities" began to be applied until April 7, 2013.

The columns in Tables 2 and 3 have been obtained in the following way:

- The column "Rate" contains the annual interest rates (i) in force at each payment date. As shown in both tables, the interest rates are revised annually (see the column "Date of interest revision");
- The column "Interests" generated during the s-th month (I_s) has been calculated, as usual, by multiplying the outstanding principal at the end of the former month (C_{s-1}) by the monthly interest rate ($i_s = i/12$):

$$I_s = C_{s-1} \times i_s.$$

For example, in Table 3, at August 7, 2000, $I_s = 150{,}000 \times 5.849/1{,}200 = 731.13$ €.

Starting date	07/07/2000
Loan principal	€150,000.00
Term	300 months
Fixed interest rate (first year)	6.000%
Variable interest rate	MLRI over three years
Period of interest revision	12 months
Starting date for applying fixed interest	07/07/2000
Starting date for applying the first variable interest	07/07/2001
Starting date for applying the second variable interest	07/07/2002
Days prior to rate specification	MLRI two months earlier
Differential	0.250% (rounded up)

Source: Own elaboration

Table 1.
Information on a basic case study

Date of interest revision	Payment date	Rate (%)	Outstanding principal (€)	Payment (€)	Interests (€)	Amortization (€)
07/07/2000	07/07/2000	–	150,000.00	–	–	–
07/07/2000, 5.522%	07/07/2000	0.000	150,000.00	0.00	0.00	–
MLRI May 2000 (rounded)	07/08/2000	6.000	149,783.55	966.45	750.00	216.45
	07/09/2000	6.000	149,566.01	966.45	748.92	217.53
	07/10/2000	6.000	149,347.39	966.45	747.83	218.62
	07/11/2000	6.000	149,127.68	966.45	746.74	219.72
	07/12/2000	6.000	148,906.86	966.45	745.64	220.81
	07/01/2001	6.000	148,684.94	966.45	744.53	221.92
	07/02/2001	6.000	148,461.92	966.45	743.42	223.03
	07/03/2001	6.000	148,237.77	966.45	742.31	224.14
	07/04/2001	6.000	148,012.51	966.45	741.19	225.26
	07/05/2001	6.000	147,786.12	966.45	740.06	226.39
	07/06/2001	6.000	147,558.60	966.45	738.93	227.52
07/07/2001, 5.926%	07/07/2001	6.000	147,329.94	966.45	737.79	228.66
MLRI March 2001 (rounded)	07/08/2001	6.250	147,108.44	988.85	767.34	221.50
	07/09/2001	6.250	146,885.78	988.85	766.19	222.66
	07/10/2001	6.250	146,661.97	988.85	765.03	223.82
	07/11/2001	6.250	146,436.99	988.85	763.86	224.98
	07/12/2001	6.250	146,210.84	988.85	762.69	226.15
	07/01/2002	6.250	145,983.51	988.85	761.51	227.33
	07/02/2002	6.250	145,754.99	988.85	760.33	228.51
	07/03/2002	6.250	145,525.29	988.85	759.14	229.70
	07/04/2002	6.250	145,294.39	988.85	757.94	230.90
	07/05/2002	6.250	145,062.28	988.85	756.74	232.10
	07/06/2002	6.250	144.828,97	988.85	755.53	233.31
⋮	⋮	⋮	⋮	⋮	⋮	⋮
	07/07/2013	3.703	*92,359.01*	795.38	286.57	508.80

Source: Own elaboration

Table 2.
Amortization with the "MLRI over three years for all financial entities"

Date of interest revision	Payment date	Rate (%)	Outstanding principal (€)	Payment (€)	Interests (€)	Amortization (€)
07/07/2000	07/07/2000	–	150,000.00	–	–	–
07/07/2000, 4.849%	07/07/2000	0.000	150,000.00	0.00	0.00	–
EURIBOR May + 1%	07/08/2000	5.849	149,778.47	952.65	731.13	221.53
	07/09/2000	5.849	149,555.86	952.65	730.05	222.61
	07/10/2000	5.849	149,332.17	952.65	728.96	223.69
	07/11/2000	5.849	149,107.38	952.65	727.87	224.78
	07/12/2000	5.849	148,881.50	952.65	726.77	225.88
	07/01/2001	5.849	148,654.52	952.65	725.67	226.98
	07/02/2001	5.849	148,426.44	952.65	724.57	228.09
	07/03/2001	5.849	148,197.24	952.65	723.46	229.20
	07/04/2001	5.849	147,966.92	952.65	722.34	230.32
	07/05/2001	5.849	147,735.48	952.65	721.22	231.44
	07/06/2001	5.849	147,502.92	952.65	720.09	232.57
07/07/2001, 4.520%	07/07/2001	5.849	147,269.22	952.65	718.95	233.70
EURIBOR May + 1%	07/08/2001	5.520	147,022.88	923.78	677.44	246.34
	07/09/2001	5.520	146,775.40	923.78	676.31	247.47
	07/10/2001	5.520	146,526.79	923.78	675.17	248.61
	07/11/2001	5.520	146,277.04	923.78	674.02	249.75
	07/12/2001	5.520	146,026.14	923.78	672.87	250.90
	07/01/2002	5.520	145,774.08	923.78	671.72	252.06
	07/02/2002	5.520	145,520.86	923.78	670.56	253.22
	07/03/2002	5.520	145,266.48	923.78	669.40	254.38
	07/04/2002	5.520	145,010.93	923.78	668.23	255.55
	07/05/2002	5.520	144,754.20	923.78	667.05	256.73
	07/06/2002	5.520	144,496.29	923.78	665.87	257.91
⋮	⋮	⋮	⋮	⋮	⋮	⋮
	07/07/2013	2.266	*89,941.16*	713.94	170.86	543.08

Source: Own elaboration

Table 3. Amortization with the EURIBOR plus a 1% spread

- The column "Payment" at the end of the s-th month (a_s) has been calculated by means of the well-known formula corresponding to the French method of amortization:

$$a_s = \frac{C_{s-1}}{a_{\overline{n-s}|i_s}}, \tag{33}$$

where $a_{\overline{n-s}|i_s} = \frac{1-(1+i_s)^{-(n-s)}}{i_s}$. For example, in Table 3, at September 7, 2000, $a_s = \frac{149{,}778.49}{a_{\overline{299}|0.05849/12}} = 952.65$ €;

- The column "Amortization" at the end of the s-th month (A_s) has been calculated as the difference between the corresponding payment (a_s) and the interests generated during the s-th month (I_s):

For example, in Table 3, at October 7, 2000, $A_s = 952.65 - 728.96 = 223.69$€; and

- Finally, the column "Outstanding principal" at the end of the s-th month (C_s) has been calculated as the difference between the outstanding principal at the end of the ($s-1$)-month (C_{s-1}) and the amortization corresponding to the s-th month (A_s):

Table 4.
Legal interest rates (%)

Year	Annual rate
2000	4.25
2001	5.50
2002	4.25
2003	4.25
2004	3.75
2005	4.00
2006	4.00
2007	5.00
2008	5.50
2009	5.50 (until March) 4.00 (since April)
2010	4.00
2011	4.00
2012	4.00
2013	4.00

Source: Own elaboration

Table 5.
Differences between interests and capitalized sum

Date	Arithmetic differences (€)	Legal interest rate (%)	Monthly legal interest rate (%)	Monthly factors	Capitalized differences (€)
07/08/2000	18.88	4.25	0.34744950	1.0034744950	32.88
07/09/2000	18.87	4.25	0.34744950	1.0034744950	32.76
07/10/2000	18.87	4.25	0.34744950	1.0034744950	32.64
07/11/2000	18.87	4.25	0.34744950	1.0034744950	32.53
07/12/2000	18.86	4.25	0.34744950	1.0034744950	32.41
07/01/2001	18.86	5.50	0.44716989	1.0044716989	32.29
07/02/2001	18.86	5.50	0.44716989	1.0044716989	32.14
07/03/2001	18.85	5.50	0.44716989	1.0044716989	31.99
07/04/2001	18.85	5.50	0.44716989	1.0044716989	31.85
07/05/2001	18.85	5.50	0.44716989	1.0044716989	31.70
07/06/2001	18.84	5.50	0.44716989	1.0044716989	31.55
07/07/2001	18.84	5.50	0.44716989	1.0044716989	31.40
07/08/2001	89.91	5.50	0.44716989	1.0044716989	149.19
07/09/2001	89.88	5.50	0.44716989	1.0044716989	148.49
07/10/2001	89.86	5.50	0.44716989	1.0044716989	147.80
07/11/2001	89.84	5.50	0.44716989	1.0044716989	147.10
07/12/2001	89.82	5.50	0.44716989	1.0044716989	146.41
07/01/2002	89.79	4.25	0.34744950	1.0034744950	145.72
07/02/2002	89.77	4.25	0.34744950	1.0034744950	145.18
07/03/2002	89.74	4.25	0.34744950	1.0034744950	144.63
07/04/2002	89.72	4.25	0.34744950	1.0034744950	144.09
07/05/2002	89.69	4.25	0.34744950	1.0034744950	143.55
07/06/2002	89.66	4.25	0.34744950	1.0034744950	143.01
⋮	⋮	⋮	⋮	⋮	⋮
07/07/2013	*8,732.43*	*Arithmetic sum and capitalized sum*			*11,486.39*

Source: Own elaboration

$$C_s = C_{s-1} - A_s.$$

For example, at November 7, 2000, $C_s = 149{,}332.17 - 224.78 = 149{,}107.38$€.

The columns in Table 5 have been obtained in the following way:

- The column "Monthly legal interest rate", denoted as i_s^l, has been calculated starting from the corresponding (annual) legal interest rates, represented as i^l (see Section 3.1), by applying the following well-known formula:

$$i_s^l = \left(1 + i^l\right)^{1/12} - 1. \tag{34}$$

For example, the first monthly interest rate is:

$$i_s^l = (1 + 0.0425)^{1/12} - 1 = 0.0034744950.$$

- The column "Monthly factors", denoted as u_s, has been determined, for each month, by the following expression:

$$u_s = 1 + i_s^l. \tag{35}$$

- Finally, the column "Capitalized differences" refers to the differences of interests, once capitalized by means of the monthly legal interest rates, and so have been calculated by expression (1) in Section 3.1.

In summary, after these calculations, the financial institution should reimburse the borrower with the amount of €11,486.39 if, instead of applying the "MLRI over three years for all financial entities," it had applied the EURIBOR plus a differential of 1%.

5. Conclusion

Since the financial crisis of 2008, the interest rates derived from the credit markets have been questioned because of the manipulation practices of banks and other financial institutions to safeguard their profitability. Thus, a high number of problems derived from the use of these interest rates have affected an increasing number of consumers. In effect, the LIBOR, EURIBOR and MLRI have caused problems of abusiveness, manipulability and lack of transparency in those loans contracted from 2008. In the case of Spain, the MLRI has not been studied in depth, which makes it necessary to quantify the economic damage that could be caused to the injured parties (Rodríguez-López *et al.*, 2021). The main objective of this article has been to quantify the excess of interests paid by consumers when applying the MLRI instead of the EURIBOR as well as to highlight the current situation of the problems that these interest rates have caused to consumers and the solutions proposed in the practice to solve the problem.

Moreover, the contributions of this article are, basically, the provision of a summary of the legal aspects and the mathematical-financial treatment for the calculation of the excess of interests paid by borrowers in mortgage loans referenced to the MLRI compared to the EURIBOR. In effect, first, it has been pointed out that the MLRI is a relatively recent index that, as stated at the beginning of this article, has undergone various changes in its regulation and application as well as in all its legal aspects. Due to the recent pronouncement of sentences that increasingly protect consumers, this index has been questioned more and more, and financial institutions have been affected by these legal resolutions. We must remember that it is a variable interest rate that changes according to the current economic situation, and this leads to various other problems, such as the lack of transparency in understanding its characteristics or its insertion in general contracting clauses.

Second, in comparison with the EURIBOR and due to the current situation, the MLRI is a highly questioned interest rate due to the economic damage caused to consumers. Because of this damage and the number of contracts in Spain, the main objective of this article is to calculate, from a financial-mathematical point of view, the excess interest paid by consumers by comparing both interest rates. As shown by the different repayment methods, both the interests and the outstanding principal of the loan are higher when applying the MLRI instead of the EURIBOR, as it is assumed that, in the first year, the applied MLRI is higher and, therefore, the outstanding principal is higher over the years, which, consequently, results in higher interests to be applied over the rest of years. Therefore, independently of the repayment method used, the application of the MLRI supposes a disadvantage for the borrower.

As a final conclusion, after the cancelation by courts of the clause containing the application of the MLRI, there are two options. On the one hand, the courts can rule that the loan contract can go ahead without applying any interest rate, or, alternatively, the application of the EURIBOR can be used as an alternative. This will be determined by the specific circumstances of the contract, and, in this context, the mathematical calculations described above can be used to determine the interests overpaid by consumers on their loans calculated through different methods. The best option for those affected by the MLRI in Spain is still not clear; perhaps a possible answer is to look at other similar cases, such as the EURIBOR or the LIBOR, which have given rise to many problems in other countries and have been studied in more depth. In any case, it remains to be investigated which is the best method and the best solution for borrowers. This work lays the theoretical foundations of the existing problems surrounding the MLRI and allows us to see the problems that the LIBOR and the EURIBOR have caused in other countries to be reflected in the Spanish case.

Due to COVID-19 pandemic, the number of legal complaints against the application of the MLRI in mortgage contracts has decreased in the last two years. Then, it is difficult to determine the number of borrowers and mortgage contracts favored by the legal sentences. Indeed, this issue remains as a future research.

Notes

1. https://peritojudicial.com/reclamar-irph/#EURIBOR%20vs%20IRPH
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Corresponding author
Salvador Cruz Rambaud can be contacted at: scruz@ual.es