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Constant-Installment Amortization Under Simple Interest: Financial Equivalence, Interest Allocation, and Present-Value Implications

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Abstract
This paper compares three distinct methodologies for amortizing loans with constant installments under the simple interest regime: the proposal of Forger (2009), the Italian approaches of Mari and Aretusi (2018, 2019) and Annibali et al. (2016, 2020), and the SACS methodology developed by De-Losso and Santos (2026). The analysis is conducted under two alternative focal dates, namely the loan origination date and the maturity date. Although the methods generate identical installment streams and total interest amounts for a given focal date, they differ in the allocation and timing of interest and amortization components. The paper also examines the equivalent representation of a financing operation as a set of multiple contracts and compares it with the traditional single-contract structure. Considering the lender's opportunity cost of capital, the results show that the timing differences in interest recognition produce significant *fiscal gain*s when multiple contracts replace a single contract. These gains arise under all methodologies and focal dates considered, suggesting that contract structuring plays a relevant role even when accounting totals remain unchanged.

Keywords: simple interest, loan amortization, constant installments, multiple contracts, financial equivalence, present value; SACS.

1. Introduction

Loan amortization systems determine not only the total amount repaid by the borrower but also the timing with which principal and interest are recognized throughout the life of a financing contract. Under compound interest, amortization systems such as the French (Price) system and the Constant Amortization System (SAC) are well established. Under the simple interest regime, however, the construction of financially consistent amortization schedules has remained controversial for decades.

The problem is particularly relevant because several judicial decisions, regulatory discussions, and academic debates have questioned the use of compound interest in specific credit operations. Consequently, financially consistent amortization systems under simple interest have attracted increasing attention in both the Brazilian and Italian literature. Despite recent advances, different

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methodologies continue to coexist, raising questions regarding their equivalence and practical implications.

Existing contributions may be divided into three main approaches. The first originates from the work of Forger (2009), who proposed constant installment schedules based on the so-called Gauss method, first proposed by Nogueira (2002). A second line of research was developed in Italy by Mari and Aretusi (2018, 2019) and subsequently extended by Annibali et al. (2016, 2020). More recently, De-Losso et al. (2013), De-Losso and Santos (2026), and de Faro and Lachtermacher (2024) proposed the SACS methodology, establishing financially consistent amortization systems under simple interest.

Although these methodologies have been studied separately, there is no comprehensive comparison of their theoretical properties under different focal dates. Moreover, the literature has not examined whether the alternative allocation of interest generated by these methods has economic consequences when financing operations are represented by equivalent collections of multiple contracts rather than by a single contract.

This paper makes four contributions. First, it provides a unified comparison of the three principal methodologies proposed for constant installment amortization under simple interest. Second, it extends the comparison to two alternative focal dates, showing how the choice of focal date affects the allocation of principal and interest while preserving financial equivalence. Third, it demonstrates that although all methods generate identical total interest, they generally produce different interest-recognition paths. Finally, it shows that these differences become economically relevant when a financing operation is represented by multiple equivalent contracts. Although nominal interest remains unchanged, the present value of the interest stream differs across contractual structures once the financial institution's opportunity cost of capital is considered. Consequently, replacing a single contract with multiple contracts systematically generates positive present-value fiscal gains.

It should be noted that Lachtermacher, De Losso and de Faro (2025), conduct a similar comparison of three distinct proposals for the amortization of a loan using the constant amortization method, when applying the simple interest regime.

Specifically, we are going to examine the case where a loan of F units of capital must be reimbursed at the periodic rate i of simple interest, by n periodic constant installments.

Since we are considering the case of the simple interest regime, it is necessary to specify a focal date, cf. Ayres (1963). This is imperative because, contrary to the case of the compound interest regime, where the choice of a particular focal date is not relevant, in the case of the simple interest regime this is crucial. As distinct focal dates lead to different results, if $n > 1$.

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This paper considers two distinct focal dates: The first, epoch zero, being the date of granting the loan; the second, epoch *n*, the term of the loan, being the date of the last payment of the financing contract.

2. Forger's Methodology

Preliminarily considering only the focal date at time *n*, the work of Forger (2009) was preceded by a proposition (Nogueira,2002), which became very popular in Brazil and has been named as the "Gauss Method".

Forger (2009) stipulates that the value ***F*** of the loan must be divided into two distinct components. One, called capitalizable and denoted as F^C, and the other, called non-capitalizable, being denoted as F^N That is, it is supposed that:

$$F = F^C + F^N \tag{1}$$

Denoting as S_k the outstanding balance at time *k*, immediately after the payment P_k, and as A_k the amortization component at time *k*, which makes up the installment P_k, it is assumed that $S_k = S_k^C + S_k^N$, $P_k = P_k^C + P_k^N$ and $A_k = A_k^C + A_k^N$ for ***k***=1, 2, …, ***n***. Furthermore, also for ***k***=1, 2, …, ***n***, it is established that:

$$S_k^C = S_{k-1}^C - A_k^C = S_{k-1}^C - P_k^C \Leftrightarrow A_k^C = P_k^C \tag{2}$$

$$S_k^N = S_k^{N-1} - A_k^N = S_{k-1}^N + I_k - P_k^N \Leftrightarrow A_k^N = P_k^N - I_k \tag{3}$$

with the simple interest rate ***i*** being applied only to the capitalizable balance S_k^C. In other words, it is assumed that:

$$I_k = i \times S_{k-1}^C \tag{4}$$

where I_k denotes the interest component of the payment P_k, for $k = 1, 2, \ldots, n$. It should be noted that this component is not subdivided.

At time zero, where the loan is granted, the introduction of a weighting factor *f* is considered, with $0 \le f \le 1$, such that:

$$F = F^C + F^N \Leftrightarrow S_0 = S_0^C + S_0^N \tag{5}$$

with $S_0^C = F \times f$, $S_0^N = F \times (1 - f)$, $F = S_0$ and the value of *f* depending on the choice of the focal date.

Additionally, as the capitalizable debt balance is supposed to decrease linearly, from its initial value $S_0^C = F \times f$, to the final value $S_n^C = 0$, and as, regardless of the amortization system that is adopted, it is established that $P^C = P_k^C = A_k^C = A^C$, whatever *k*, we have that:

$$P^C = A^C = \frac{F}{n} \times f \tag{6}$$

Consequently, using the recursion given by (2), we obtain:

$$S_k^C = F \times f - k \times P^C = F \times f \times \left(\frac{n-k}{n} \right),\ k = 0,1,\ldots,n \tag{7}$$

Therefore, considering relationship (4), it follows that:

$$I_k = S_{k-1}^C \times i = F \times f \times i \times \left(\frac{n-k+1}{n} \right),\ k = 1,2,\ldots,n \tag{8}$$

As we are focusing here on the case of constant payments, when $P_k = P = P^C + P^N$, with $P^C = F \times f / n$, for ***k***=1, 2, …, ***n***, considering, recursively, relation (3) and, as demonstrated in Lachtermacher & de Faro (2023b), we have:

$$S_k^N = F \times (1-f) - \sum_{\ell=1}^{k} A_\ell^N,\ k = 1,2,\ldots,n \tag{9}$$

$$A_k^N = P^N - F \times f \times i + (k-1) \times i \times P^C,\ k = 1,2,\ldots,n \tag{10}$$

$$P^N = \left(\frac{F}{n} \right) \times \left[1 - f + \frac{f \times i \times (n+1)}{2} \right] \tag{11}$$

2.1 Focal Date at Time 0

In this case, which was not addressed by Forger (2009), since only the focal date at time *n* was considered. Denoting as P_k the k^{th} payment, the equivalence between *F* and the sequence of the *n* payments implies that:

$$F = \sum_{k=1}^{n} \frac{P_k}{1 + i \times k} \tag{12}$$

Thus, in the case of a constant installment, equal to *P*, we will have:

$$P = F \times \sum_{k=1}^{n} (1 + i \times k)^{-1} \tag{13}$$

Following the generalization presented in Lachtermacher and de Faro (2023b), which extended the work of Forger (2009) to the case of focal date at time zero, the value of the weighting factor *f* has a complex analytical solution, given by:

$$f = \left(\frac{n}{\sum_{k=1}^{n} \frac{1}{(1 + k \times i)}} - 1 \right) \times \frac{2}{i \times (n+1)} \tag{14}$$

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As numerical example considers the case where $F = \$100,000.00$, $i = 1\%$ per period, and $n = 12$ periods.

Regarding the value of the parameter *f*, is necessary to solve equation (14) or making use of the methodology developed in Lachtermacher and de Faro (2023b), it can be shown that $f = 0.982771415$. Accordingly, the solution is $P = \$8,865.67$.

Table 1. Constant Installments – Forger (2009) – Focal Date *t* = 0

k	I_k	$A_k^C = P_k^C$	A_k^N	P_k^N	S_k^N	S_k^C	S_k
0					1,722.86	98,277.14	100,000.00
1	982.77	8,189.76	-306.87	675.91	2,029.72	90,087.38	92,117.10
2	900.87	8,189.76	-224.97	675.91	2,254.69	81,897.62	84,152.31
3	818.98	8,189.76	-143.07	675.91	2,397.76	73,707.86	76,105.62
4	737.08	8,189.76	-61.17	675.91	2,458.93	65,518.09	67,977.03
5	655.18	8,189.76	20.73	675.91	2,438.21	57,328.33	59,766.54
6	573.28	8,189.76	102.62	675.91	2,335.59	49,138.57	51,474.16
7	491.39	8,189.76	184.52	675.91	2,151.07	40,948.81	43,099.87
8	409.49	8,189.76	266.42	675.91	1,884.65	32,759.05	34,643.70
9	327.59	8,189.76	348.32	675.91	1,536.33	24,569.29	26,105.62
10	245.69	8,189.76	430.21	675.91	1,106.12	16,379.52	17,485.64
11	163.80	8,189.76	512.11	675.91	594.01	8,189.76	8,783.77
12	81.90	8,189.76	594.01	675.91	0.00	0.00	0.00
∑	6,388.01	98,277.14	1,722.86	8,110.87			

This method, considering the concept introduced by de Faro (2014), has been proved to be financially consistent in Lachtermacher e de Faro (2023a).

2.2 Focal Date at Epoch n

In this case, denoting as P_k the k^{th} payment, the equivalence of *F* and the sequence of *n* payments imply that:

$$F \times (1 + i \times n) = \sum_{k=1}^{n} P_k \times \left[1 + i \times (n - k)\right] \tag{15}$$

Therefore, in the case of *n* constant payments equal to *P*, we have the following analytical solution:

$$P = \frac{F \times (1 + i \times n)}{n \times \left\{1 + \left[i \times \frac{(n-1)}{2}\right]\right\}} \tag{16}$$

A solution that is also presented in Nogueira (2002). Since $P = P^N + P^C$, and $P^C = F \times f / n$ we have $P^N = P - P^C$.

As for the corresponding value of the parameter *f*, we can make use directly of Forger (2009):

$$f = \left[1 + i \times \frac{(n-1)}{2}\right]^{-1} \tag{17}$$

In the case of our numerical example, noticing that we have $f = 0.947867299$, Table 2 presents the corresponding evolution of the debt.

Table 2. Constant Installments – Forger (2009) – Focal Date *t* = *n*

k	I_k	$A_k^C = P_k^C$	A_k^N	P_k^N	S_k^N	S_k^C	S_k
0					5,213.27	94,786.73	100,000.00
1	947.87	7,898.89	0.00	947.87	5,213.27	86,887.84	92,101.11
2	868.88	7,898.89	78.99	947.87	5,134.28	78,988.94	84,123.22
3	789.89	7,898.89	157.98	947.87	4,976.30	71,090.05	76,066.35
4	710.90	7,898.89	236.97	947.87	4,739.34	63,191.15	67,930.49
5	631.91	7,898.89	315.96	947.87	4,423.38	55,292.26	59,715.64
6	552.92	7,898.89	394.94	947.87	4,028.44	47,393.36	51,421.80
7	473.93	7,898.89	473.93	947.87	3,554.50	39,494.47	43,048.97
8	394.94	7,898.89	552.92	947.87	3,001.58	31,595.58	34,597.16
9	315.96	7,898.89	631.91	947.87	2,369.67	23,696.68	26,066.35
10	236.97	7,898.89	710.90	947.87	1,658.77	15,797.79	17,456.56
11	157.98	7,898.89	789.89	947.87	868.88	7,898.89	8,767.77
12	78.99	7,898.89	868.88	6,161.14	0.00	0.00	0.00
∑	6,161.14	94,786.73	5,213.27	16.587,68	5,213.27	94.786,73	100,000.00

This method has also been proved to be financially consistent in de Faro and Lachtermacher (2024).

3. The "Gauss[1] Method"

On the grounds that the compound interest regime implies the occurrence of anatocism, which an anathema in several judicial courts in Brazil, cf. de Faro and Guerra (2014), it has been frequently determined that financial contracts originally written in terms of the compound interest regime had to be substituted in accordance with the so-called "Gauss Method"; cf.

[1] It should be emphasized that it is not proper to associate the name of the outstanding mathematician Carl Friedrich Gauss (1777-1855) to what, in Brazil, has been named as the "Gauss Method". According to legend it is said that a very young Gauss, at seven or eight years of age, was able to show, very quickly, that the sum of the first 100 natural numbers is equal to 5,050. However, the general formula of the sum of the terms of an arithmetic progression was already known since the $5.^{th}$century BC.

Antonick and Assunção (2006) and Nogueira (2013). Which is based on the simple interest regime.

Following Nogueira (2013), and observing that the value of the constant periodic instalment P is given by formula (15), the first step for the determination of the outstanding debt at time k, denoted as S_k, for $k = 0,1,\ldots,n$, is to define a weight-index WI given by:

$$WI = 2 \times i \times \frac{F}{n \times \left[2 + i \times (n-1)\right]} \tag{18}$$

from which it is determined that the k^{th} parcel of interest of the constant installment P denoted as I_k, is equal to:

$$I_k = (n+1-k) \times WI, \text{ for } k = 1,2,\ldots,n \tag{19}$$

with the correspondent parcel of amortization, A_k, being:

$$A_k = P_k - I_k = P - I_k \quad , \; k = 1,2,\ldots,n \tag{20}$$

Then, following de Faro (2016), we have:

$$S_k = F \times \left\{1 - k \times \frac{\left[2 + i \times (k-1)\right]}{n \times \left[2 + i \times (n-1)\right]}\right\} \quad , \; k = 0,1,\ldots,n \tag{21}$$

However, for instance, considering our numerical example, the evolution of the debt would be the same as in Table 2 if you consolidate capitalized and non-capitalized parts of all terms, as shown in Table 3.

Table 3. Constant Installments – Gauss Method – Focal Date $t = n$

k	I_k	A_k	P_k	S_k
0	-	-	-	100,000.00
1	947.87	7,898.89	8,846.76	92,101.11
2	868.88	7,977.88	8,846.76	84,123.22
3	789.89	8,056.87	8,846.76	76,066.35
4	710.90	8,135.86	8,846.76	67,930.49
5	631.91	8,214.85	8,846.76	59,715.64
6	552.92	8,293.84	8,846.76	51,421.80
7	473.93	8,372.83	8,846.76	43,048.97
8	394.94	8,451.82	8,846.76	34,597.16
9	315.96	8,530.81	8,846.76	26,066.35
10	263.97	8,609.79	8,846.76	17,456.56
11	157.98	8,688.78	8,846.76	8,767.77
12	78.99	8,767.77	8,846.76	0.00
∑	6,161.14	100,000.00	106,161.14	

Therefore, and this is a general result, the so-called "Gauss Method", as originally presented in Nogueira (2013), coincides with Forger (2009) methodology when considering the focal date at time *n*.

At this juncture it is pertinent to stress, as pointed out in de Faro (2016) and De-Losso et al. (2020) that there is a limit for the use of relation (16), since, even increasing indefinitely the value of the interest rate *i*, we would have $P < \frac{2 \times F}{n-1}$.

4. The Italians Proposals

Proceeding in chronological order, this section address the procedures that have been considered in the Italian literature.

4.1 The Mari and Aretusi (2018) and (2019) Proposal - Focal Date at Epoch 0

In this case, which considers equation (13), relative to focal date at epoch zero, we will have the same constant installments as in the case of Forger (2009).

$$P = F \times \sum_{k=1}^{n} \left(1 + i \times k\right)^{-1} \tag{22}$$

So that, in the case of our numerical example, we will also have the constant value $P = \$8,865.67$.

Making use of the same notation previously presented, we have that the amortization component of the k^{th} payment P_k is $A_k = S_k - S_{k-1},$ for $k = 1, 2, \ldots, n;$ with $S_0 = F.$

On the other hand, Mari and Aretusi (2019) postulated that:

$$S_k = \left[F - P \times \sum_{\ell=1}^{k} \left(1 + i \times \ell\right)^{-1} \right] \times \left(1 + i \times k\right),\ k = 1, 2, \ldots, n \tag{23}$$

As for the interest component, Mari and Aretusi (2018) postulated that:

$$I_k = S_{k-1} \times \frac{i}{1 + i \times \left(k - 1\right)},\ k = 1, 2, \ldots, n \tag{24}$$

So that, in the case of constant instalments, we have:

$$P = A_k + i \times \frac{S_{k-1}}{1 + i \times \left(k - 1\right)} \quad , \text{ for } k = 1, 2, \ldots, n \tag{25}$$

where, as already mentioned the value of *P* is given by (22).

At this point it is worth noticing that we have:

$$\sum_{k=1}^{n} I_k = i \times \sum_{k=1}^{n} \frac{S_{k-1}}{1 + i \times \left(k - 1\right)} = n \times P - F \tag{26}$$

which is the same result presented in section 2.1. Therefore, from the strict account point of view, there is no difference in the results.

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However, as will be shown, we have significant differences when the cost of capital of the financing institution providing the loan is considered.

For the case of our numerical example, it follows that the corresponding evolution of the debt is as presented in Table 4.

Table 4. Constant Instalments – Mari & Aretusi Method – Focal Date $t = 0$

k	I_k	A_k	P_k	S_k
0				100,000.00
1	1,000.00	7,865.67	8,865.67	92,134.33
2	912.22	7,953.45	8,865.67	84,180.89
3	825.30	8,040.37	8,865.67	76,140.52
4	739.23	8,126.44	8,865.67	68,014.08
5	653.98	8,211.69	8,865.67	59,802.39
6	569.55	8,296.12	8,865.67	51,506.27
7	485.91	8,379.76	8,865.67	43,126.51
8	403.05	8,462.62	8,865.67	34,663.90
9	320.96	8,544.71	8,865.67	26,119.19
10	239.63	8,626.04	8,865.67	17,493.15
11	159.03	8,706.64	8,865.67	8,786.51
12	79.16	8,786.51	8,865.67	0.00
∑	6,388.01	100,000.00	106,388.01	

Since the instalments are the same, the difference between this method and Forger's is in the division between interest and amortization parts.
This method has also been proved to be financially consistent in de Faro and Lachtermacher (2024).

4.2. The Annibali et. al. (2016, 2020) Proposal - Focal Date at Epoch n

Although Mari and Aretusi (2019) also considered the case of focal date at time *n*, they have explicitly stated that the focal date at the time the loan is contracted, time 0, is the one that is more adequate.

Therefore, for the case of focal date at the end of the term of the contract, time *n*, we will follow the presentation of Annibali et al. (2016, 2020).

The equivalence of F and the sequence of n payments is given by equation (15). From which follows the solution given by (16).

It was established that the outstanding debt at epoch k is such that:

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$$S_k = P \times (n-k) \times \frac{\left[1 + i \times \frac{(n-k-1)}{2}\right]}{\left[1 + i \times (n-k)\right]} \quad , k = 1, 2, \ldots, n \tag{27}$$

Making use of the same notation previously presented, we have that the amortization component of the k^{th} payment P_k is $A_k = S_k - S_{k-1}$, for $k = 1, 2, \ldots, n$; with $S_0 = F$.
With the value of the k^{th} parcel of interest being:

$$I_k = \frac{i \times S_{k-1}}{1 + i \times (n-k)} \quad , k = 1, 2, \ldots, n \tag{28}$$

Therefore, in the case of our numerical example, the evolution of the debt is as presented in Table 5.

Table 5. Constant Instalments – Annibali et al. – Focal Date $t = n$

k	I_k	A_k	P_k	S_k
0				100,000.00
1	900.90	7,945.86	8,846.76	92,054.14
2	836.86	8.009,91	8,846.76	84,044.23
3	771.05	8,075.71	8,846.76	75,968.52
4	703.41	8,143.35	8,846.76	67,825.17
5	633.88	8,212.88	8,846.76	59,612.29
6	562.38	8,284.38	8,846.76	51,327.91
7	488.84	8,357.92	8,846.76	42.969.98
8	413.17	8,433.59	8,846.76	34,536.40
9	335.30	8,511.46	8,846.76	26,024.94
10	255.15	8,591.61	8,846.76	17,433.32
11	172.61	8,674.15	8,846.76	8,759.17
12	87.59	8,759.17	8,846.76	0.00
∑	6,161.14	100,000.00	106,161.14	

Since the installments are the same in Table 2 and 5, the difference between this method and Forger's is in the division between interest and amortization parts.

Comparing the results presented in Table 2 and 5, we have the same total amounts of interest and amortization. However, both sequences differ.

However, as the sequences of interests are different, a more relevant comparison should also consider the financial institution cost of capital. Exactly as was pointed out in the case of focal date at epoch 0.

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This method has also been proved to be financially consistent in de Faro and Lachtermacher (2024).

5. The De-Losso et al. Proposal - SACS

In what can be deemed as a seminal contribution, De-Losso et al. (2013) extended the idea previously suggested in Sandrini (2007) and in Vieira Sobrinho (2012) and developed the concept of substituting a single amortization contract by multiple ones. One for each of the *n* payments of the single contract.

In a more recent contribution, De-Losso and Santos (2026), in a critical analysis of the concept of anatocism, also developed procedures for systems of amortization using the simple interest regime.

5.1 Focal Date at Epoch 0

In this case, which consider equation (12), relative to focal date at epoch zero, we will have the same installments as in the case of Forger (2009). That is:

$$P = \frac{F}{\sum_{k=1}^{n}(1+i\times k)^{-1}} \tag{29}$$

And it is supposed that the k^{th} parcel of interest is equal to:

$$I_k = i \times D_k \tag{30}$$

where D_k denotes the unpaid portion of the original debt F. That is

$$D_k = \begin{cases} F & ,k=1 \\ F - \sum_{\ell=1}^{k-1} \dfrac{P}{1+i\times\ell} & ,k=2,3,...,n \end{cases} \tag{31}$$

with

$$A_k = P - I_k \quad ,k=1,2,\ldots,n \tag{32}$$

and

$$S_k = S_{k-1} - A_k \quad ,k=1,2,\ldots,n \tag{33}$$

and $S_0 = F$.

For the case of our numerical example, Table 6 presents the corresponding evolution of the debt.

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Table 6. Constant Installments – De Losso et al. – Focal Date $t = 0$

k	A_k	D_k	I_k	P_k	S_k
0					100,000.00
1	7,865.67	100,000.00	1,000.00	8,865.67	92,134.33
2	7,953.45	91,222.11	912.22	8,865.67	84,180.89
3	8,040.37	82,530.28	825.30	8,865.67	76,140.52
4	8,126.44	73,922.84	739.23	8,865.67	68,014.08
5	8,211,69	65,398.15	653.98	8865.67	59,802.39
6	8,296,12	56,954.66	569.55	8,865.67	51,506.27
7	8,379,76	48,590.82	485.91	8,865.67	43,126.51
8	8,462,62	40,305.15	403.05	8,865.67	34,663.90
9	8,544,71	32,096.20	320.96	8,865.67	26,119.19
10	8,626,04	23,962.56	239.63	8,865.67	17,493.15
11	8,706,64	15,902.86	159.03	8,865.67	8,786.51
12	8,786,51	7,915.77	79.16	8,865.67	0.00
Σ	100,000,00	638,801.42	6,388.01	106,388.01	

This method has also been proved to be financially consistent.

As can be seen in the case of our numerical example, we also have the same total of interest sequences that was observed in the previous two cases. So that, from the strict accounting point of view, there is no difference between them.

However, similarly as was previously pointed out, the timing and values of the corresponding parcels are not equal. Which implies that we should consider the cost of capital of the financial institution providing the loan.

5.2 Focal Date at Epoch n

Analogously to the other two preceding cases, the value of the constant instalment is P is also given by relation (16).

Since the interest rate will be applied to the unpaid portion of the debt on epoch zero, to find the interest parcel I_k, it is necessary to determine the value of an equivalent interest rate i_{eq}, such that:

$$F = P \times \sum_{k=1}^{n} \left(1 + i_{eq} \times k\right)^{-1} \tag{34}$$

This can be accomplished, for instance, using the Excel© Goal Seek function.

Given the value of i_{eq}, we will have:

$$I_k = i_{eq} \times D_k \quad , k = 1, 2, \ldots, n \tag{35}$$

so that

$$D_k = \begin{cases} F & , k = 1 \\ F - \sum_{\ell=1}^{k-1} \dfrac{P}{1 + i_{eq} \times \ell} & , k = 2, 3, \ldots, n \end{cases} \tag{36}$$

with:

$$A_k = P - I_k \quad , k = 1, 2, \ldots, n \tag{37}$$

and

$$S_k = S_{k-1} - A_k \quad , k = 1, 2, \ldots, n \tag{38}$$

and $S_0 = F$.

In the case of our numerical example, the corresponding evolution of the debt is presented in Table 7.

Table 7. Constant Installments – De Losso et al. – Focal Date $t = n$

k	A_k	D_k	I_k	P_k	S_k
0					100,000.00
1	7,882.85	100,000.00	963.91	8,846.76	92,117.15
2	7,967.31	91,237.70	879.45	8,846.76	84,149.83
3	8,050.97	82,558.26	795.79	8,846.76	76,098.86
4	8,133.85	73,960.13	712.91	8,846.76	67,965.01
5	8,215.96	65,441.81	630.80	8,846.76	59,749.05
6	8,297.32	57,001.82	549.45	8,846.76	51,451.73
7	8,377.93	48,638.73	468.83	8,846.76	43,073.80
8	8,457.81	40,351.16	388.95	8,846.76	34,615.99
9	8,536.98	32,137.76	309.78	8,846.76	26,079.01
10	8,615.45	23,997.20	231.31	8,846.76	17,463.56
11	8,693.23	15,928.22	153.53	8,846.76	8,770.33
12	8,770.33	7,929.56	76.43	8,846.76	0.00
Σ	100,000.00	639,182.35	6,161.14	106,161.14	

This method has also proved to be financially consistent.

Similarly to the previous two corresponding cases, the total payments of interest are the same. However, once more, the timing and values of the corresponding parcels are not the same.

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6. Multiple Contracts

Rather than engaging in a single contract, the financial institution has the option of requiring the borrower to adhere to *n* subcontracts; one for each of the *n* payments that would be associated with the case of a single contract. With the principal of the k^{th} subcontract being the present value, at the same simple interest rate *i*, of the k^{th} payment of the single contract.
Considering the two focal dates, we have.

6.1 Focal Date at Epoch 0

Adapting to the case of simple interest the proposition in De-Losso et al. (2013), the principal of the k^{th} individual contract denoted, as F_k, will be equal to the present value, now at the rate *i* of simple interest, of the k^{th} payment of the single contract. That, for the constant instalment method, is:

$$F_k = \frac{P}{1+i\times k} \quad , \quad k=1,2,\ldots,n \tag{39}$$

with the parcel of amortization, $\bar{A}_k$ corresponding to the k^{th} payments P_k, being exactly equal to F_k. Therefore, from an accounting point of view, the parcel of interest associated to the k^{th} payment $\bar{P}_k = P$, denoted as $\bar{I}_k$ will be:

$$\bar{I}_k = P - \bar{A}_k = P\times\left[1-\left(1+i\times k\right)^{-1}\right] \quad , \quad k=1,2,\ldots,n \tag{40}$$

From a strict accounting point of view, not taking into consideration the costs that may be associated with the bookkeeping and registration of the subcontracts, the total interest payments are the same in both cases. However, in terms of present values, and depending on the financial institution opportunity cost, it is possible that the financial institution will be better off if it adopts the multiple contracts option.

Since all methods that have been considered using, the focal date at epoch zero, present the same sequence of payments (Tables 1,4 and 6), they will present the same multiple contracts components, presented in Table 8.

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Table 8. Multiple Contracts –Focal Date $t = 0$

k	$F_k = \bar{A}_k$	$\bar{I}_k$	$\bar{P}_k = P_k$
1	8,777.89	87.78	8,865.67
2	8,691.83	173.84	8,865.67
3	8,607.44	258.22	8,865.67
4	8,524.68	340.99	8,865.67
5	8,443.49	422.17	8,865.67
6	8,363.84	501.83	8,865.67
7	8,285.67	580.00	8,865.67
8	8,208.95	656.72	8,865.67
9	8,133.64	732.03	8,865.67
10	8,059.70	805.97	8,865.67
11	7,987.09	878.58	8,865.67
12	7,915.77	949.89	8,865.67
$\sum$	100,000.00	6,388.01	106,388.01

Table 9 presents the interests sequences of Table 1, and Table 8, as well as their difference Δ_k .

Table 9. Forger - Interest Difference – Δ_k

Focal Date t=0

k	I_k	$\bar{I}_k$	Δ_k
1	982.77	87.78	89.99
2	900.87	173.84	727.04
3	818.98	258.22	560.75
4	737.08	340.99	396.09
5	655.18	422.17	233.01
6	573.28	501.83	71.45
7	491.39	580.00	-88.61
8	409.49	656.72	-247.23
9	327.59	732.03	-404.44
10	245.69	805.97	-560.28
11	163.80	878.58	-714.78
12	81.90	949.89	-868.00
$\sum$	6,388.01	6,388.01	0.00

Table 10 presents the interests sequences of Table 4, and Table 8, as well as their difference Δ_k .

Table 10. Mari & Aretusi - Interest Difference – Δ_k

Focal Date t=0

k	I_k	$\bar{I}_k$	Δ_k
1	1,000.00	87.78	912.22
2	912.22	173.84	738.38
3	825.30	258.22	567.08
4	739.23	340.99	398.24
5	653.98	422.17	231.81
6	569.55	501.83	67.72
7	485.91	580.00	-94.09
8	403.05	656.72	-253.66
9	320.96	732.03	-411.07
10	239.63	805.97	-566.34
11	159.03	878.58	-719.55
12	79.16	949.89	-870.74
$\sum$	6,388.01	6,388.01	0.00

Table 11 presents the interests sequences of Table 6, and Table 8, as well as their difference Δ_k .

Table 11. De Losso et al. - Interest Difference – Δ_k

Focal Date t=0

k	I_k	$\bar{I}_k$	Δ_k
1	1,000.00	87.78	912.22
2	912.22	173.84	738.38
3	825.30	258.22	567.08
4	739.23	340.99	398.24
5	653.98	422.17	231.81
6	569.55	501.83	67.72
7	485.91	580.00	-94.09
8	403.05	656.72	-253.66
9	320.96	732.03	-411.07
10	239.63	805.97	-566.34
11	159.03	878.58	-719.55
12	79.16	949.89	-870.74
$\sum$	6,388.01	6,388.01	0.00

From Table 8, 9 and 10 we can see that the Forger method leads to different interests' sequence of the other methods. While Mari & Aretusi and De Losso et al. present the same interest sequence using different methods.

However, all total interests' sequences amounts are the same. The Forger one presents a different sequence of the other two methods. So, we should consider the capital cost of the financial institution to find out which methods bring the best fiscal gain.

6.2. Focal Date at Epoch n

On the other hand, if the focal date is at epoch *n*, it is necessary to make a further adaptation. To ensure that the sum of the subcontract's value is equal to value *F* of the single contract, it is necessary that, as shown in Lachtermacher and de Faro (2023b):

$$F_k = P_k \times \frac{1+i\times(n-k)}{1+i\times n} \quad , \quad k=1,2,\ldots,n \tag{41}$$

The parcel of amortization, $\bar{A}_k$ associated with the k^{th} payment is exactly equal to the value of the corresponding principal. On the other hand, the parcel of interest, denoted as $\bar{I}_k$ will be equal to:

$$\bar{I}_k = P_k \times \frac{1-\left[1+i\times(n-k)\right]}{1+i\times n} \quad , \quad k=1,2,\ldots,n \tag{42}$$

Since all methods that have been presented using, the focal date at epoch *n*, presents the same sequence of payments (Tables 2, 5 and 7) they will present the same multiple contracts, presented in Table 12.

Table 12. Multiple Contracts – Focal Date *t* = *n*

k	$F_k = \bar{A}_k$	$\bar{I}_k$	$\bar{P}_k = P_k$
1	8,767.77	78.99	8,846.76
2	8,688.78	157.98	8,846.76
3	8,609.79	236.97	8,846.76
4	8,530.81	315.96	8,846.76
5	8,451.82	394.94	8,846.76
6	8,372.83	473.93	8,846.76
7	8,293.84	552.92	8,846.76
8	8,214.85	631.91	8,846.76
9	8,135.86	710.90	8,846.76
10	8,056.87	789.89	8,846.76
11	7,977.88	868.88	8,846.76
12	7,898.89	947.87	8,846.76
∑	100,000.00	6,161.14	106,161.14

Table 13 presents the interests sequences of Table 2, and Table 12, as well as their difference Δ_k .

Table 13. Forger - Interest Difference – Δ_k

Focal Date $t = n$

k	I_k	$\bar{I}_k$	Δ_k
1	947.87	78.99	868.88
2	868.88	157.98	710.90
3	789.89	236.97	552.92
4	710.90	315.96	394.94
5	631.91	394.94	236.97
6	552.92	473.93	78.99
7	473.93	552.92	-78.99
8	394.94	631.91	-236.97
9	315.96	710.90	-394.94
10	236.97	789.89	-552.92
11	157.98	868.88	-710.90
12	78.99	947.87	-868.88
$\sum$	6,161.14	6,161.14	0.00

Table 14 presents the interests sequences of Table 5, and Table 12, as well as their difference Δ_k .

Table 14. Annibali et al. - Interest Difference – Δ_k

Focal Date $t = n$

k	I_k	$\bar{I}_k$	Δ_k
1	900.90	78.99	821.91
2	836.86	157.98	678.88
3	771.05	236.97	534.08
4	703.41	315.96	387.46
5	633.88	394.94	238.94
6	562.38	473.93	88.45
7	488.84	552.92	-64.09
8	413.17	631.91	-218.74
9	335.30	710.90	-375.60
10	255.15	789.89	-534.74
11	172.61	868.88	-696.27
12	87.59	947.87	-860.28
$\sum$	6,161.14	6,161.14	0.00

Table 15 presents the interests sequences of Table 7, and Table 12, as well as their difference Δ_k .

Table 15. De Losso et al. - Interest Difference – Δ_k

	Focal Date $t = n$		
k	I_k	$\bar{I}_k$	Δ_k
1	963.91	78.99	884.92
2	879.45	157.98	721.47
3	795.79	236.97	558.82
4	712.91	315.96	396.95
5	630.80	394.94	235.85
6	549.45	473.93	75.51
7	468.83	552.92	-84.09
8	388.95	631.91	-242.96
9	309.78	710.90	-401.12
10	231.31	789.89	-558.58
11	153.53	868.88	-715.34
12	76.43	947.87	-871.43
$\sum$	6,161.14	6,161.14	0.00

It should be noted that all three methods presented different interest sequences, but with the same total amount. So, we should consider the capital cost of the financial institution to find out which methods bring the best fiscal gain.

7. Fiscal Gains Analysis

Nevertheless, from an accounting perspective, there are no apparent differences, since the total interest is the same in both simple and multiple cases, on both focal dates, the tax gain for the entity providing the financing must be duly considered.

It is important to note that the succession of differences presents a single sign variation on the two focal dates, for all methods. According to Faro (1974), this characterizes what is called a conventional financing project. To which a single internal rate of return is associated. Which, on both focal dates and all methods, is zero.

Denoting by ρ the periodic compound interest rate that identifies the so-called opportunity cost for the financial institution, the present value, denoted by $V^s(\rho)$, of the interest payments, in the case of a single contract, is equal to:

$$V^s(\rho) = \sum_{k=1}^{n} I_k \times (1+\rho)^{-k} \tag{43}$$

where the rate ρ is relative to the same period as rate i. Whereas, in the case of multiple contracts, the corresponding present value, $V^m(\rho)$, will be:

$$V^m(\rho) = \sum_{k=1}^{n} \bar{I}_k \times (1+\rho)^{-k} \tag{44}$$

As will be shown, the percentage tax gain, $\delta(\%)$, is defined as:

$$\delta(\%) = 100 \times \left[\frac{V^s(\rho)}{V^m(\rho)} - 1 \right] \tag{45}$$

It is always extremely significant in all cases.

7.1 Focal Date at Epoch t=0

As illustrated in Tables 16, 17 and 18 for the Forger's Method, when the annual equivalent value of the rate ρ is identified as ρ_a, and the financing terms are expressed in annual terms, it is found that the fiscal gain is extremely significant.

Table 16. Forger – $\delta(\%)$ – i = 0,5% Monthly
Focal Date t = 0

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	7.928	16.037	24.298	32.686	41.174	49.739
10	15.954	33.233	51.655	71.019	91.112	111.730
15	23.989	51.147	80.875	112.467	145.214	178.493
20	32.044	69.511	110.902	154.541	198.971	243.132
25	40.109	88.015	140.670	195.080	249.131	301.662
30	48.164	106.349	169.301	232.698	294.217	353.017

Table 17. Forger – $\delta(\%)$ – i = 1,0% Monthly
Focal Date t = 0

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	7.626	15.394	23.277	31.249	39.287	47.369
10	14.989	31.018	47.898	65.428	83.413	101.671
15	22.152	46.655	72.877	100.157	127.896	155.611
20	29.185	62.146	97.372	133.431	169.236	204.109
25	36.108	77.277	120.627	163.843	205.588	245.318
30	42.919	91.841	142.120	190.772	236.644	279.617

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Table 18. Forger – $\delta(\%)$ – i = 2,0% Monthly

Focal Date t = 0

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	7.182	14.451	21.783	29.155	36.544	43.932
10	13.768	28.243	43.232	58.547	74.019	89.498
15	20.045	41.582	63.983	86.674	109.192	131.209
20	26.129	54.443	83.527	112.255	139.925	166.204
25	32.056	66.706	101.420	134.594	165.576	194.307
30	37.835	78.249	117.427	153.611	186.563	216.664

As illustrated in Tables 19, 20 and 21 for the Mari & Aretusi's Method, it is found that the fiscal gain is also extremely significant.

Table 19. Mari and Aretusi – $\delta(\%)$ – i = 0,5% Monthly

Focal Date t = 0

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	11.154	19.429	27.861	36.422	45.087	53.831
10	16.661	34.771	54.141	74.557	95.796	117.639
15	26.362	55357	87.280	121.380	156.891	193.125
20	35.212	76.054	121.595	169.988	219.582	269.143
25	43.977	97.358	156.778	218.786	280.849	341.513
30	53.557	119.639	192.277	266.287	338.704	408.324

Table 20. Mari and Aretusi – $\delta(\%)$ – i = 1,0% Monthly

Focal Date t = 0

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	10.804	18.884	27.090	35.398	43.780	52.216
10	16.145	33.519	51.916	71.115	90.899	111.061
15	25.251	52.572	82.106	113.106	144.874	176.830
20	33.507	71.359	112.443	155.046	197.803	239.810
25	41.626	90.328	142.671	195.692	247.538	297.335
30	50.385	109.762	172.353	234.061	293.018	348.757

Table 21. Mari and Aretusi – $\delta(\%)$ – i = 2,0% Monthly

Focal Date t = 0

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	10.324	18.119	25.999	33.938	41.913	49.903
10	15.491	31.941	49.129	66.833	84.847	102.987
15	23.989	49.416	76.295	103.910	131.657	159.080
20	31.686	66.398	102.920	139.729	175.777	210.475
25	39.223	83.289	128.842	173.462	215.933	255.880
30	47.276	100.324	153.766	204.561	251.771	295.501

And finally, as illustrated in Tables 22, 23 and 24 for the SACS's Method, the fiscal gain is also extremely significant.

Table 22. SACS – $\delta(\%)$ – i =0,5% Monthly

Focal Date t = 0

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	8.118	16.429	24.905	33.518	42.241	51.050
10	16.661	34.771	54.141	74.557	95.796	117.639
15	25.498	54.572	86.592	120.796	156.410	192.739
20	34.612	75.548	121.196	169.691	219.372	268.999
25	43.977	97.358	156.778	218.786	280.849	341.513
30	53.557	119.639	192.277	266.287	338.704	408.324

Table 23. SACS – $\delta(\%)$ – i = 1,0% Monthly

Focal Date t = 0

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	7.962	16.087	24.346	32.713	41.160	49.665
10	16.145	33.519	51.916	71.115	90.899	111.061
15	24.483	51.891	81.524	112.625	144.487	176.526
20	32.983	70.932	112.119	154.813	197.643	239.703
25	41.626	90.328	142.671	195.692	247.538	297.335
30	50.385	109.762	172.353	234.061	293.018	348.757

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Table 24. SACS – $\delta(\%)$ – i = 2,0% monthly

Focal Date t = 0

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	7.732	15.583	23.526	31.534	39.581	47.646
10	15.491	31.941	49.129	66.833	84.847	102.987
15	23.313	48.833	75.811	103.521	131.353	158.847
20	31.227	66.040	102.659	139.549	175.657	210.398
25	39.223	83.289	128.842	173.462	215.933	255.880
30	47.276	100.324	153.766	204.561	251.771	295.501

As be seen Tables 19, 20 and 21 are respectively identical to Tables 22, 23 and 24, since both methods presented the identical interest and payments sequences.

In other words, the financial institution should opt to replace a single contract with multiple contracts, since $V^s(\rho) > V^m(\rho)$ applies to all cases studied.

7.2 Focal Date at Epoch n

As illustrated in Tables 25, 26 and 27 for the Forger's Method, when the annual equivalent value of the rate ρ is identified as ρ_a, and the financing terms are expressed in annual terms, it is found that the fiscal gain is extremely significant.

Table 25. Forger – $\delta(\%)$ – i = 0,5% Monthly

Focal Date $t = n$

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	8.321	16.874	25.633	34.569	43.655	52.866
10	17.467	36.740	57.668	80.058	103.686	128.319
15	27.332	59.489	96.038	136.274	179.340	224.354
20	37.937	85.199	140.670	202.396	268.149	335.910
25	49.303	113.865	191.100	276.711	366.418	457.004
30	61.440	145.388	246.557	357.133	470.600	583.041

Table 26. Forger – $\delta(\%)$ – i = 1,0% Monthly

Focal Date $t = n$

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	8.321	16.874	25.633	34.569	43.655	52.866
10	17.467	36.740	57.668	80.058	103.686	128.319
15	27.332	59.489	96.038	136.274	179.340	224.354
20	37.937	85.199	140.670	202.396	268.149	335.910
25	49.303	113.865	191.100	276.711	366.418	457.004
30	61.440	145.388	246.557	357.0133	470.600	583.041

Table 27. Forger – $\delta(\%)$ – i = 2,0% monthly

Focal Date $t = n$

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	8.321	16.874	25.633	34.569	43.655	52.866
10	17.467	36.740	57.668	80.058	103.686	128.319
15	27.332	59.489	96.038	136.274	179.340	224.354
20	37.937	85.199	140.670	202.396	268.149	335.910
25	49.303	113.865	191.100	276.711	366.418	457.004
30	61.440	145.388	246.557	357.133	470.600	583.041

As illustrated in Tables 28, 29 and 30 for the Annibali's Method, it is found that the fiscal gain is also extremely significant.

Table 28. Annibali et al.– $\delta(\%)$ – i = 0,5% Monthly

Focal Date $t = n$

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	14.438	22.323	30.361	38.530	46.806	55.169
10	15.415	32.273	50.439	69.742	89.993	110.995
15	24.064	50.626	80.408	112.833	147.227	182.914
20	31.433	68.661	111.564	158.645	208.269	258.996
25	38.463	87.336	144.538	206.948	271.602	336.361
30	46.439	107.650	179.646	257.067	335.666	413.013

Table 29. Annibali et al.– $\delta(\%)$ – i = 1,0% Monthly

Focal Date $t = n$

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	13.950	21.375	28.933	36.603	44.366	52.200
10	14.195	29.656	46.257	63.845	82.249	101.294
15	21.901	45.846	72.589	101.617	132.339	164.160
20	28.328	61.613	99.845	141.711	185.779	230.795
25	34.446	78.021	128.908	184.377	241.832	299.392
30	41.519	96.086	160.230	229.239	299.358	368.423

Table 30. Annibali et al.– $\delta(\%)$ – i = 2,0% Monthly

Focal Date $t = n$

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	13.240	20.025	26.922	33.910	40.974	48.094
10	12.774	26.642	41.497	57.202	73.609	90.565
15	19.668	41.015	64.831	90.670	118.012	146.337
20	25.398	55.152	89.357	126.858	166.385	206.813
25	30.916	70.111	116.003	166.156	218.219	270.473
30	37.432	86.856	145.202	208.194	272.367	335.695

As illustrated in Tables 31, 32 and 33 for the SACS's Method, it is found that the fiscal gain is also extremely significant.

Table 31. SACS – $\delta(\%)$ – i = 0,5% Monthly

Focal Date $t = n$

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	8.495	17.237	26.196	35.344	44.652	54.094
10	18.082	38.095	59.884	83.251	107.963	133.776
15	28.591	62.421	101.059	143.772	189.651	237.754
20	40.020	90.305	149.739	216.260	287.461	361.128
25	52.378	121.758	205.512	299.020	397.564	497.523
30	65.675	156.701	267.603	389.832	516.048	641.712

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Table 32. SACS – $\delta(\%)$ – i=1,0% Monthly

Focal Date $t = n$

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	8.611	17.477	26.569	35.858	45.314	54.911
10	18.387	38.768	60.992	84.854	110.120	136.538
15	29.091	63.596	103.087	146.823	193.876	243.278
20	40.712	92.022	152.825	221.026	294.161	369.945
25	53.257	124.052	209.764	305.686	406.968	509.866
30	66.738	159.602	273.098	398.491	528.225	657.584

Table 33. SACS – $\delta(\%)$ – i=2,0% Monthly

Focal Date $t = n$

	$\rho_a(\%)$					
n(years)	5.00%	10.00%	15.00%	20.00%	25.00%	30.00%
5	8.754	17.776	27.034	36.499	46.141	55.933
10	18.690	39.441	62.102	86.466	112.295	139.330
15	29.527	64.627	104.876	149.524	197.631	248.204
20	41.265	93.405	155.324	224.905	299.635	377.175
25	53.917	125.789	213.002	310.788	414.199	519.391
30	67.501	161.699	277.092	404.820	537.163	669.276

In other words, the financial institution should opt to replace a single contract with multiple contracts, since $V^s(\rho) > V^m(\rho)$ applies to all cases studied.

8. Comparison Among the Three Single Contracts

In the previous section it was verified that, for all the three distinct amortization methods that have been under our scrutiny, and for the two focal dates considered, the best option for the financing institution providing the loan is the implementation of multiple contracts.

However, so far, nothing has been said about which single contract option should be the one implemented by the financing institution.

To this end we will extend the analysis presented in de Faro and Lachtermacher (2024), to include the SACS proposal of De-Losso and Santos (2023).

Our aim is, considering each of the two focal dates, to determine which method yields the smallest present value of the corresponding tax sequence.

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8.1 Focal Date at Epoch 0

8.1.1 Comparing Forger (SPC) x De-Losso and Santos (SACS)

Table 34 presents the sequences of interest payments, according to SPC (I_k - Table 1) and SACS (I'_k - Table 6), as well as their differences. Denoted as $d_k^1 = I_k - I'_k;\ \text{for}\ k = 1,2,\ldots,n.$

Table 34. SPC x SACS – Focal Date at Epoch 0

Time (k)	I_k	I'_k	$d_k^1 = I_k - I'_k$
1	982.77	1,000.00	-17.23
2	900.87	912.22	-11.35
3	818.98	825.30	-6.33
4	737.08	739.23	-2.15
5	655.18	653.98	1.20
6	573.28	569.55	3.74
7	491.39	485.91	5.48
8	409.49	403.05	6.44
9	327.59	320.96	6.63
10	245.69	239.63	6.07
11	163.80	159.03	4.77
12	81.90	79.16	2.74
Σ	6,388.01	6,388.01	0.00

As depicted, the total interest payments are equal and the sequence of differences has only one sign of change, indicating that the sequence of differences has a unique internal rate of return, as shown in de Faro (1974).

Figure 1 shows the interest sequences of the SPC and SACS methods for a 60-months term and focal date at epoch 0 and simple monthly interest rates of 0.5%, 1% and 2.0%. It is worth noting that the decrease in the value of the interest sequence of the SPC method is linear while that of the SACS method is exponential, with the initial values of the sequence of the SACS method being greater than those of the SPC method.

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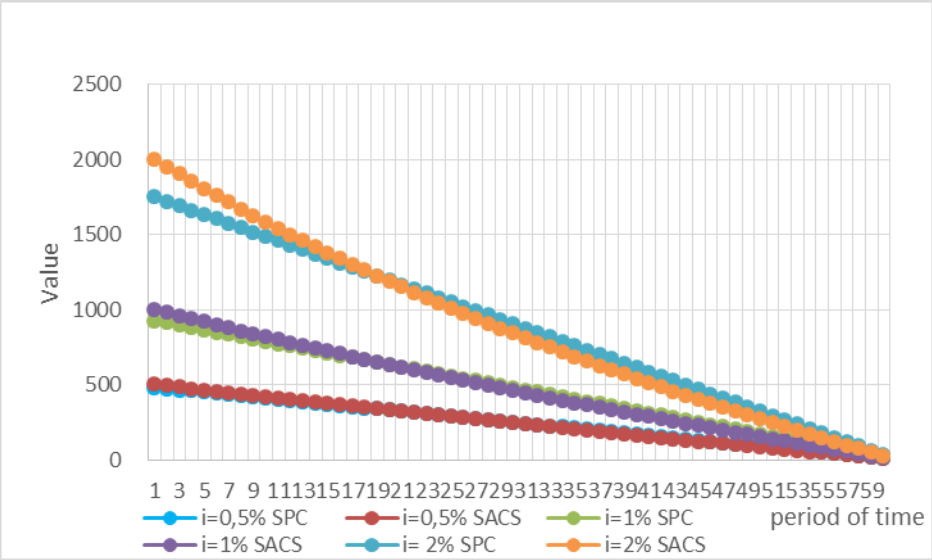


Figure 1. Interest Comparison SPC and SACS - Focal Date t=0 – n=60

Tables 35 and 36 compare the tax gain δ, between the Forger and SACS methods, given by the percentage difference of the present value of the interest sequence at rate ρ. Where ρ is the periodic rate that identifies the cost of capital of the financial institution.

Denoting

$$V^0_{SPC}(\rho) = \sum_{k=0}^{n} I_k \times (1+\rho)^{-k}$$

and

$$V^0_{SACS}(\rho) = \sum_{k=0}^{n} I'_k \times (1+\rho)^{-k}$$

we have:

$$\delta(\%) = \left[V^0_{SPC}(\rho) / V^0_{SACS}(\rho) - 1\right] \times 100 \qquad (46)$$

Table 35. Comparison Fiscal Gain δ – SPC x SACS, F. Date t=0, i = 1% Monthly

	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	-0.3109	-0.5967	-0.8598	-1.1025	-1.3268	-1.5343
10	-0.9957	-1.8731	-2.6447	-3.3235	-3.9213	-4.4492
15	-1.8727	-3.4474	-4.7638	-5.8637	-6.7859	-7.5634
20	-2.8558	-5.1406	-6.9522	-8.3912	-9.5439	-10.4782
25	-3.8964	-6.8571	-9.0837	-10.7709	-12.0705	-13.0915
30	-4.9648	-8.5435	-11.1007	-12.9582	-14.3437	-15.4069

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Table 36. Comparison Fiscal Gain δ – SPC x SACS, F. Date t=0, i = 2% Monthly

	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	-0.5105	-0.9794	-1.4109	-1.8085	-2.1757	-2.5155
10	-1.4912	-2.8026	-3.9544	-4.9667	-5.8580	-6.6450
15	-2.6500	-4.8724	-6.7279	-8.2782	-9.5789	-10.6772
20	-3.8850	-6.9845	-9.4405	-11.3938	-12.9624	-14.2378
25	-5.1475	-9.0479	-11.9829	-14.2134	-15.9390	-17.3016
30	-6.4102	-11.0198	-14.3201	-16.7290	-18.5370	-19.9335

Where ρ_a denotes the opportunity cost in annual terms. As we can see, there is a predominance of one method over the other, since the results present only negative values. Negative values mean that the SPC method presents a lower present value of the interest sequence, that is, a lower payment of fees. While positive values mean the opposite.

8.1.2 Comparing Forger (SPC) x Mari & Aretusi (M&A)

Table 37 presents the sequences of interest payments, according to SPC (I_k - Table 1) and M&A (I_k'' - Table 4), as well as their differences. Denoted as $d_k^2 = I_k - I_k''$; for $k = 1,2,\ldots,n$.

Table 37. SPC x M&A – Focal Date at Time 0

Time (k)	I_k	I_k''	$d_k^2 = I_k - I_k''$
1	982.77	1.000.00	-17.23
2	900.87	912.22	-11.35
3	818.98	825.30	-6.33
4	737.08	739.23	-2.15
5	655.18	653.98	1.20
6	573.28	569.55	3.74
7	491.39	485.91	5.48
8	409.49	403.05	6.44
9	327.59	320.96	6.63
10	245.69	239.63	6.07
11	163.80	159.03	4.77
12	81.90	79.16	2.74
Σ	6,388.01	6,388.01	0.00

As depicted, the total interest payments are equal and the sequence of differences has only one sign of change, indicating that the sequence of differences has a unique internal rate of return, as

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shown in de Faro (1974). It should be noted that the sequence of interest of the SACS and M&A methods are identical.

Figure 2 shows the interest sequences of the SPC and M&A methods for a 60-months term and focal date at epoch 0 and simple monthly interest rates of 0.5%, 1% and 2.0%. It is worth noting that the decrease in the value of the interest sequence of the SPC method is linear while that of the M&A method is exponential, with the initial values of the sequence of the M&A method being greater than those of the SPC method. Figure 1 and 2 are identical, since SACS and M&A present the same interest sequence.

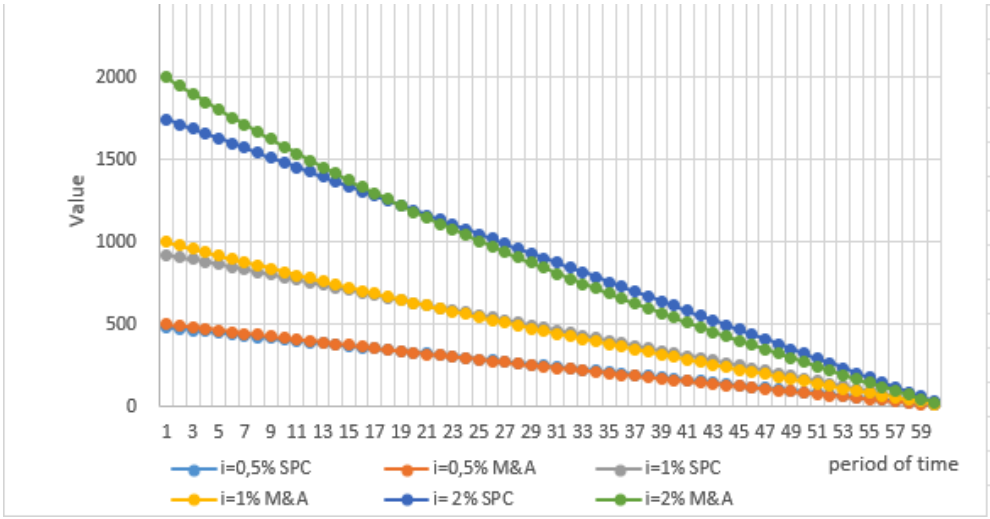


Figure 2 Interest Comparison SPC and M&A - F. Date *t*=0 – n=60

Tables 35 and 36 compare the tax gain δ, between the Forger and M&A methods, given by the percentage difference of the present value of the interest sequence at rate ρ. Where ρ is the periodic rate that identifies the cost of capital of the financial institution.
Denoting

$$V_{SPC}^{0}(\rho)=\sum_{k=0}^{n} I_k \times (1+\rho)^{-k}$$

and

$$V_{M\&A}^{0}(\rho)=\sum_{k=0}^{n} I'_k \times (1+\rho)^{-k}$$

we have:

$$\delta(\%)=\left[V_{SPC}^{0}(\rho)/V_{M\&A}^{0}(\rho)-1\right]\times 100 \qquad (47)$$

Table 35. Comparison Fiscal Gain δ – SPC x M&A, F. Date *t*=0, *i* = 1% Monthly

	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	-0.3109	-0.5967	-0.8598	-1.1025	-1.3268	-1.5343
10	-0.9957	-1.8731	-2.6447	-3.3235	-3.9213	-4.4492
15	-1.8727	-3.4474	-4.7638	-5.8637	-6.7859	-7.5634
20	-2.8558	-5.1406	-6.9522	-8.3912	-9.5439	-10.4782
25	-3.8964	-6.8571	-9.0837	-10.7709	-12.0705	-13.0915
30	-4.9648	-8.5435	-11.1007	-12.9582	-14.3437	-15.4069

Table 36. Comparison Fiscal Gain δ – SPC x M&A, F. Date *t*=0, *i* = 2% monthly

	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	-0.5105	-0.9794	-1.4109	-1.8085	-2.1757	-2.5155
10	-1.4912	-2.8026	-3.9544	-4.9667	-5.8580	-6.6450
15	-2.6500	-4.8724	-6.7279	-8.2782	-9.5789	-10.6772
20	-3.8850	-6.9845	-9.4405	-11.3938	-12.9624	-14.2378
25	-5.1475	-9.0479	-11.9829	-14.2134	-15.9390	-17.3016
30	-6.4102	-11.0198	-14.3201	-16.7290	-18.5370	-19.9335

Where ρ_a denotes the opportunity cost in annual terms. As we can see, there is a predominance of one method over the other, since the results present only negative values. Negative values mean that the SPC method presents a lower present value of the interest sequence, that is, a lower payment of fees. While positive values mean the opposite.

8.1.3 Comparing De Losso et al. (SACS) x Mari & Aretusi (M&A)

Since both methods present identical interest sequences from the point of view of the financing institution there is no predominance of one over the other.

8.2 Focal Date at Epoch n

8.2.1 Comparing Forger (SPC) x De-Losso and Santos (SACS)

Table 37 presents the sequences of interest payments, according to SPC (I_k - Table 2) and SACS (I'_k - Table 7), as well as their differences. Denoted as $d_k^1 = I_k - I'_k;\ \text{for}\ k = 1,2,\ldots,n.$

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Table 37. SPC x SACS – Focal Date at Time *n*

Time (k)	I_k	I'_k	$d_k^1 = I_k - I'_k$
1	947.87	963.91	-16.04
2	868.88	879.45	-10.57
3	789.89	795.79	-5.90
4	710.90	712.91	-2.01
5	631.91	630.80	1.11
6	552.92	549.45	3.48
7	473.93	468.83	5.10
8	394.94	388.95	6.00
9	315.96	309.78	6.18
10	236.97	231.31	5.66
11	157.98	153.53	4.44
12	78.99	76.43	2.56
Σ	6,161.14	6,161.14	0.00

As depicted, the total interest payments are equal and the sequence of differences has only one sign of change, indicating that the sequence of differences has a unique internal rate of return, as shown in de Faro (1974).

Figure 3 shows the interest sequences of the SPC and SACS methods for a 60-months term and focal date at epoch *n* and simple monthly interest rates of 0.5%, 1% and 2.0%. It is worth noting that the decrease in the value of the interest sequence of the SPC method is linear while that of the SACS method is exponential, with the initial values of the sequence of the SACS method being greater than those of the SPC method.

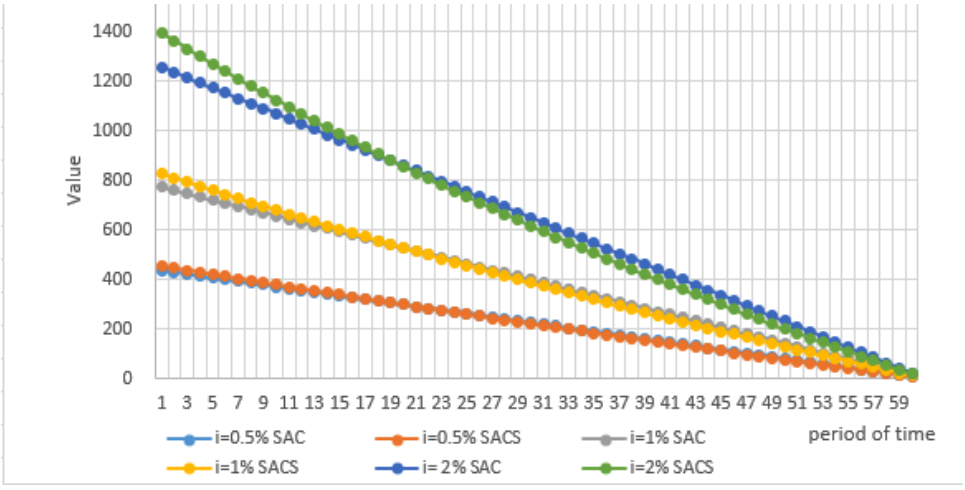


Figure 3. Interest Comparison SPC and SACS - Focal Date *t*=*n* – n=60

Tables 38 and 39 compare the tax gain δ, between the Forger and SACS methods, given by the percentage difference of the present value of the interest sequence at rate ρ. Where ρ is the periodic rate that identifies the cost of capital of the financial institution.

Denoting

$$V_{SPC}^{n}(\rho)=\sum_{k=0}^{n} I_k \times (1+\rho)^{-k}$$

and

$$V_{SACS}^{n}(\rho)=\sum_{k=0}^{n} I'_k \times (1+\rho)^{-k}$$

we have:

$$\delta(\%)=\left[V_{SPC}^{n}(\rho)/V_{SACS}^{n}(\rho)-1\right]\times 100 \qquad (48)$$

Table 38. Comparison Fiscal Gain δ – SPC x SACS, F. Date *t=n, i* = 1% monthly

	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	-0.2674	-0.5133	-0.7397	-0.9486	-1.1416	-1.3203
10	-0.7766	-1.4616	-2.0644	-2.5948	-3.0621	-3.4747
15	-1.3627	-2.5106	-3.4711	-4.2737	-4.9463	-5.5128
20	-1.9715	-3.5530	-4.8076	-5.8033	-6.5992	-7.2424
25	-2.5801	-4.5468	-6.0252	-7.1421	-7.9985	-8.6678
30	-3.1774	-5.4754	-7.1136	-8.2967	-9.1727	-9.8395

Table 39. Comparison Fiscal Gain δ – SPC x SACS, F. Date *t=n, i* = 2% monthly

	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	-0.3988	-0.7653	-1.1027	-1.4137	-1.7011	-1.9670
10	-1.0298	-1.9371	-2.7351	-3.4368	-4.0550	-4.6008
15	-1.6950	-3.1211	-4.3137	-5.3102	-6.1455	-6.8495
20	-2.3553	-4.2426	-5.7394	-6.9278	-7.8785	-8.6479
25	-2.9981	-5.2811	-6.9976	-8.2955	-9.2921	-10.0723
30	-3.6182	-6.2327	-8.0976	-9.4464	-10.4468	-11.2099

Where ρ_a denotes the opportunity cost in annual terms. As we can see, there is a predominance of one method over the other, since the results present only negative values. Negative values mean that the SPC method presents a lower present value of the interest sequence, that is, a lower payment of fees. While positive values mean the opposite.

8.2.2 Comparing Forger (SPC) x Annibali et al. (A&a)

Table 40 presents the sequences of interest payments, according to SPC (I_k - Table 2) and A&a (I_k'' - Table 5), as well as their differences. Denoted as $d_k^2 = I_k - I_k''$; for $k = 1, 2, \ldots, n$.

Table 40. SPC x A&a – Focal Date at Time *n*

Time (*k*)	I_k	I_k''	$d_k^2 = I_k - I_k''$
1	947.87	900.90	46.97
2	868.88	836.86	32.02
3	789.89	771.05	18.84
4	710.90	703.41	7.49
5	631.91	633.88	-1.97
6	552.92	562.38	-9.46
7	473.93	488.84	-14.90
8	394.94	413.17	-18.23
9	315.96	335.30	-19.35
10	236.97	255.15	-18.18
11	157.98	172.61	-14.63
12	78.99	87.59	-8.60
Σ	6,161.14	6,161.14	0.00

As depicted, the total interest payments are equal and the sequence of differences has only one sign of change, indicating that the sequence of differences has a unique internal rate of return, as shown in de Faro (1974).

Figure 4 shows the interest sequences of the SPC and A&a methods for a 60-months term and focal date at epoch *n* and simple monthly interest rates of 0.5%, 1% and 2.0%. It is worth noting that the decrease in the value of the interest sequence of the SPC method is linear while that of the SACS method is exponential, with the initial values of the sequence of the SACS method being greater than those of the SPC method.

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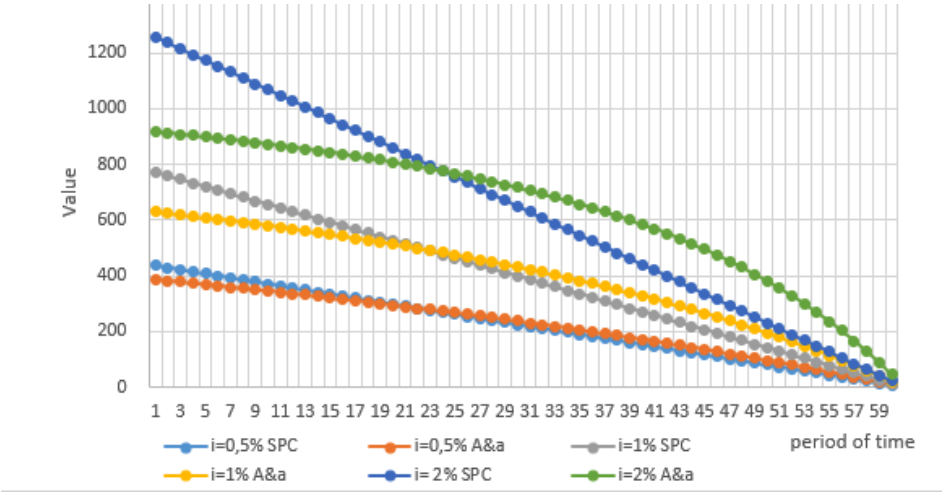


Figure 4 Interest Comparison SPC and A&a - Focal Date $t=n$ - $n=60$

Tables 41 and 42 compare the tax gain δ, between the Forger and A&a methods, given by the percentage difference of the present value of the interest sequence at rate ρ. Where ρ is the periodic rate that identifies the cost of capital of the financial institution.
Denoting

$$V_{SPC}^{n}(\rho)=\sum_{k=0}^{n} I_k \times (1+\rho)^{-k}$$

and

$$V_{A\&a}^{n}(\rho)=\sum_{k=0}^{n} I_k'' \times (1+\rho)^{-k}$$

we have:

$$\delta(\%)=\left[V_{SPC}^{n}(\rho)/V_{A\&a}^{n}(\rho)-1\right]\times 100 \qquad (48)$$

Table 41. Comparison Fiscal Gain δ – SPC x A&a, F. Date $t=n$, i = 1% monthly

	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	0.9090	1.7531	2.5373	3.2663	3.9445	4.5759
10	2.8651	5.4638	7.8022	9.8953	11.7626	13.4258
15	5.3427	10.0592	14.1334	17.6042	20.5389	23.0144
20	8.1127	15.0452	20.7385	25.3115	28.9538	31.8585
25	11.0503	20.1346	27.1688	32.4688	36.4466	39.4631
30	14.0768	25.1428	33.1733	38.8453	42.8794	45.8172

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Table 42. Comparison Fiscal Gain δ – SPC x A&a, F. Date $t=n$, i = 2% monthly

	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	1.4617	2.8258	4.0985	5.2860	6.3944	7.4296
10	4.1619	7.9734	11.4291	14.5393	17.3246	19.8114
15	7.3008	13.8243	19.5012	24.3538	28.4582	31.9137
20	10.6332	19.8331	27.4242	33.5146	38.3418	42.1649
25	14.0448	25.7209	34.7664	41.5380	46.5716	50.3495
30	17.4689	31.3245	41.3350	48.3264	53.2360	56.7706

Where ρ_a denotes the opportunity cost in annual terms. As we can see, there is a predominance of one method over the other, since the results present only positive values. Positive values mean that the A&a method presents a lower present value of the interest sequence, that is, a lower payment of fees. While negative values mean the opposite.

8.2.3 Comparing De Losso et al. (SACS) x Annibali et al. (A&a)

Table 43 presents the sequences of interest payments, according to SACS (I'_k - Table 6) and A&a (I''_k - Table 5), as well as their differences. Denoted as $d_k^3 = I'_k - I''_k;\ \text{for}\ k = 1,2,\ldots,n.$

Table 43. SACS x A&a – Focal Date at Time n

Time (k)	I'_k	I''_k	$d_k^3 = I'_k - I''_k$
1	963.91	900.90	63.01
2	879.45	836.86	42.59
3	795.79	771.05	24.74
4	712.91	703.41	9.50
5	630.80	633.88	-3.08
6	549.45	562.38	-12.93
7	468.83	488.84	-20.00
8	388.95	413.17	-24.22
9	309.78	335.30	-25.53
10	231.31	255.15	-23.84
11	153.53	172.61	-19.07
12	76.43	87.59	-11.16
Σ	6,161.14	6,161.14	0.00

As depicted, the total interest payments are equal and the sequence of differences has only one sign of change, indicating that the sequence of differences has a unique internal rate of return, as shown in de Faro (1974).

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Figure 5 shows the interest sequences of the SACS and A&a methods for a 60-months term and focal date at epoch *n* and simple monthly interest rates of 0.5%, 1% and 2.0%. It is worth noting that the decrease in the value of the interest sequence of the SACS method and A&a method, are not linear, with the initial values of the sequence of the SACS method being greater than those of the A&a method.

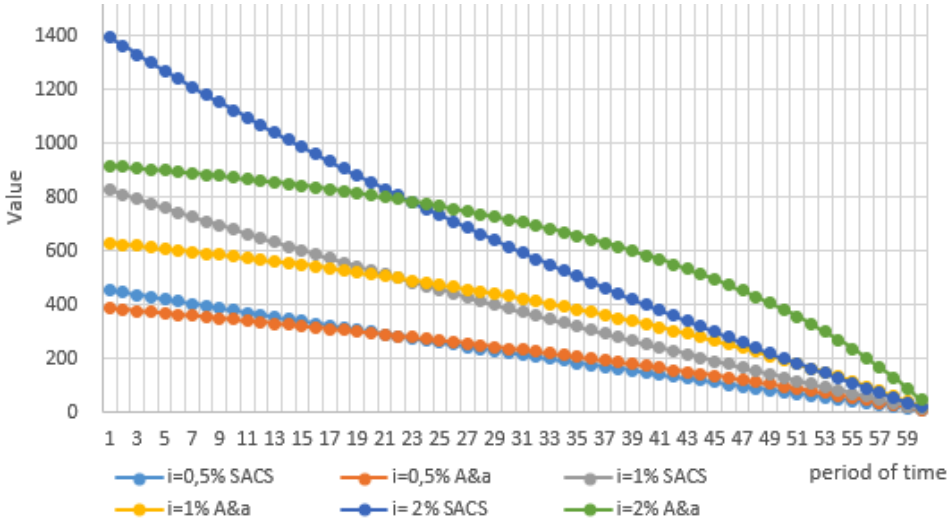


Figure 5. Interest Comparison SACS and A&a - F. Date $t=n-n=60$

Tables 44 and 45 compare the tax gain δ, between the Forger and A&a methods, given by the percentage difference of the present value of the interest sequence at rate ρ. Where ρ is the periodic rate that identifies the cost of capital of the financial institution.

Denoting

$$V_{SACS}^{n}(\rho)=\sum_{k=0}^{n} I_k \times (1+\rho)^{-k}$$

and

$$V_{A\&a}^{n}(\rho)=\sum_{k=0}^{n} I_k'' \times (1+\rho)^{-k}$$

we have:

$$\delta(\%)=\left[V_{SACS}^{n}(\rho)/V_{A\&a}^{n}(\rho)-1\right]\times 100 \qquad (49)$$

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Table 44. Comparison Fiscal Gain δ – SACS x A&a, F. Date *t*=*n*, *i* = 1% monthly

	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	1.1795	2.2781	3.3015	4.2553	5.1448	5.9751
10	3.6703	7.0281	10.0746	12.8229	15.2930	17.5089
15	6.7980	12.8935	18.2375	22.8546	26.8114	30.1916
20	10.2870	19.2833	26.8364	33.0317	38.0650	42.1538
25	13.9914	25.8570	35.3223	42.6575	48.3091	52.6987
30	17.8204	32.3918	43.3723	51.4071	57.3088	61.7307

Table 45. Comparison Fiscal Gain δ – SACS x A&a, F. Date *t*=*n*, *i* = 2% monthly

	ρ_a(%)					
n(years)	5%	10%	15%	20%	25%	30%
5	1.8680	3.6188	5.2591	6.7958	8.2356	9.5851
10	5.2457	10.1063	14.5624	18.6159	22.2831	25.5895
15	9.1509	17.4913	24.8884	31.3275	36.8695	41.6136
20	13.3019	25.1423	35.1829	43.4526	50.1733	55.6230
25	17.5697	32.7306	44.9063	54.3414	61.5864	67.1893
30	21.8787	40.0536	53.7881	63.7996	71.1117	76.5630

Where ρ_a denotes the opportunity cost in annual terms. As we can see, there is a predominance of one method over the other, since the results present only positive values. Positive values mean that the SACS method presents a lower present value of the interest sequence, that is, a lower payment of fees. While negative values mean the opposite.

9. Conclusion

In this article, we have compared three different systems with constant installments in simple capitalization regime, using two focal dates, at the beginning and end of the financing. These methods were developed by Forger (2009) extended by Lachtermacher and de Faro(2023b), De-Losso and Santos (2023), in Brazil, and in Italy, by Annibali et al. (2016 and 2020) and Mari & Aretusi (2018 and 2019).

The main objective of these comparisons is to understand the fiscal implications of replacing a single contract with multiple payments with multiple contracts, each involving a single payment. However, an approach that evaluates the total economic gains of one alternative over another requires the preparation of a free cash flow statement to firm and to equity, coupled with analyses involving both companies and individuals, since the implications are likely to differ.
In all the analyses performed, the result varies with the financing company's cost of capital, Multiple Contracts' performance overcomes the respective single contract.

In the case of a single contract analysis, the best option varies on the focal date chosen. Considering the focal date at the beginning of the contract (t=0), the best option is to use the Forger-de Faro & Lachtermacher methodology. The other two methods presented identical results.

Considering the focal date at the end of the contract (t=*n*), the best option is the methodology developed by Annibali et al., followed by the De Losso et al. methodology and by the Forger-de Faro & Lachtermacher methodology.

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