MEASURING LOST PROFITS IN FORENSIC ACCOUNTING: A QUANTITATIVE APPROACH TO THE CONSTRUCTION OF TECHNICAL EVIDENCE

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ABSTRACT

This article proposes a quantitative methodology for measuring lost profits within the scope of forensic accounting, employing the times series econometric approach as a tool for projecting a company's economic and financial performance. Using simulated data, the study constructs a time series to estimate the potential revenue in a counterfactual scenario, followed by monetary correction and application of statutory interest, following the parameters established by Constitutional Amendment No. 113/2021. The simulation was performed using Stata 17, and updated values were calculated through the PROJEF Web platform. The results demonstrate the applicability of econometric modelling as technical support for expert evidence, providing greater rigour, transparency, and foundation in the quantification of economic damages in legal proceedings.

Keywords: Forensic Accounting. Lost Profits; Times Series Models; Expert Evidence. Monetary Correction.

MENSURAÇÃO DO LUCRO CESSANTE NA PERÍCIA CONTÁBIL: UMA ABORDAGEM QUANTITATIVA PARA A CONSTRUÇÃO DA PROVA TÉCNICA

RESUMO

Este artigo propõe uma metodologia quantitativa para a mensuração do lucro cessante no âmbito da perícia contábil, utilizando ferramentas econométricas de séries temporais para projetar o desempenho econômico-financeiro de uma empresa. Com base em dados simulados, o estudo apresenta a construção de uma série temporal para estimar o faturamento potencial da empresa em situação contrafactual, bem como os procedimentos de atualização monetária e aplicação de juros legais, realizados com base nos parâmetros estabelecidos pela Emenda

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Constitucional nº 113/2021. A simulação foi conduzida no software Stata 17, e os valores corrigidos foram calculados utilizando o sistema PROJEF Web. Os resultados demonstram a aplicabilidade da modelagem econométrica como suporte à prova técnica pericial, conferindo maior rigor, transparência e fundamentação à apuração de danos patrimoniais no contexto judicial.

Palavras-chave: Perícia Contábil. Lucro Cessante. Séries Temporais. Prova Técnica. Atualização Monetária.

1 INTRODCUTION

In an increasingly juridical-economic environment permeated by disputes involving matters of high technical complexity, forensic accounting emerges as one of the principal instruments for the production of evidence within judicial proceedings. Its relevance extends beyond the mere collection of financial data, constituting a specialized field of knowledge that integrates accounting, economic, statistical, and legal dimensions, with the purpose of supporting decisions that demand technical rigor and impartiality.

According to Sá (2010), forensic accounting consists of a technical and scientific examination aimed at establishing the material truth in situations involving assets or economic activities, and is essential for ensuring the accuracy and reliability of the information submitted to the court. From Hoog's (2022) perspective, the forensic examination represents a function of significant social and legal responsibility, as the expert acts as an "interpreter of accounting science" within the forensic environment, responsible for translating complex data into comprehensible, well-substantiated reports that are useful for judicial decision-making.

In this regard, forensic accounting evidence occupies a strategic position within the evidentiary framework, particularly in cases involving the assessment of material damages, economic losses, and lost profits. Its credibility and effectiveness are strongly linked to the application of rigorous technical methods and to the objectivity with which the work is conducted, requiring from the expert not only technical mastery but also analytical and argumentative capacity. The use of quantitative techniques, such as financial projections, statistical models, discounted cash flow analyses, and simulations, constitutes a distinctive element that enhances the quality of forensic evidence and contributes to the legitimacy of judicial decisions.

Among the various objects of forensic accounting, lost profits play a central role in disputes involving revenue losses or the frustration of legitimate expectations of gain. As established in Article 402 of the Brazilian Civil Code, lost profits represent the earnings that the aggrieved party would reasonably have obtained had the unlawful act, contractual breach, or harmful event not occurred (Brasil, 2015). Their measurement, however, requires methodological rigor and solid technical grounding, as it involves a projection based on hypothetical assumptions whose plausibility must be supported by objective, historical, and comparative elements.

Within this context, the present article aims to examine the measurement of lost profits through a quantitative approach applied to forensic accounting, with particular emphasis on the use of time-series econometric models, discussing their foundations, advantages, and limitations in the production of expert evidence. From an econometric perspective, the study seeks to contribute to the enhancement of forensic practice and to strengthen the role of accounting as an auxiliary science in the pursuit of justice.

2 THEORETICAL FRAMEWORK

2.1 Foresnse Accounting as na Instrument for the Production of Thecnical Evidence

Forensic accounting constitutes one of the most relevant evidentiary mechanisms in contemporary civil procedure, particularly in disputes involving matters of high technical complexity that demand specialized knowledge. It is a regulated technical-professional activity, grounded in ethical, scientific, and legal principles, whose purpose is to analyze, interpret, and translate economic and financial data into language that is clear and accessible to the court.

In this context, Sá (2010) states that forensic accounting is an essential activity for the administration of justice, as it seeks to ascertain the material truth through the rigorous application of scientific accounting knowledge. The expert's role, therefore, goes beyond the mere presentation of numbers: it requires the construction of technically grounded arguments that confer credibility and robustness to the evidence produced.

Similarly, Hoog (2022) and Sá (2010) emphasize that forensic accounting performs a function of public interest, since the expert acts as an interpreter of accounting science within the forensic environment, directly contributing to the judge's understanding of technical matters that exceed the boundaries of legal expertise. According to the authors, modern forensic examination must rely on formal procedures, structured methodologies, and mathematical and economic foundations, especially in situations requiring financial projections, such as the measurement of lost profits.

The credibility of expert evidence is closely linked to the expert's impartiality and the technical quality of the work performed. A well-executed forensic examination is capable of reducing legal uncertainties and promoting fairer decisions, provided that the report is supported by objective criteria, is technically clear, and respects the principles of adversarial proceedings and ample defense, as prescribed by the legal system (Wakim & Wakim, 2012).

Additionally, Gruszczyński (2022) notes that the primary objective of forensic accounting is to establish material truth in disputes involving financial issues through investigations and evaluations that allow the production of reliable and technically supported reports, which are fundamental to the judicial or arbitral decision-making process.

Timchenko, Fugger, Gonzalez-Pola, and Lynggaard (2022) also reinforce the growing importance of forensic accounting as an applied scientific discipline, especially given the increasing complexity of modern economic relations. The authors highlight that expert examination has become an essential technical tool across different sectors of the economy, due to its ability to clarify economic facts in a structured and methodologically sound manner.

Thus, it becomes evident that forensic accounting plays a strategic role in the production of specialized technical evidence, serving as a key element in supporting judicial decisions based on objective evidence, scientific rigor, and normative grounding

2.2 Expert Evidence in the 2015 Brazilian Code of Civil Procedure

The 2015 Brazilian Code of Civil Procedure (CPC) reaffirmed and expanded the importance of expert evidence within the national procedural system by more precisely defining the criteria for admissibility, the procedures for its production, and its evidentiary value. According to Article 464, expert evidence shall be admitted whenever the verification of disputed facts requires specialized technical or scientific knowledge. Under such circumstances, the appointed expert must conduct their work guided by the principles of impartiality and objectivity and must be available to provide additional clarifications when requested by the parties or the court (Brasil, 2015). The appointment of the expert, in turn, is provided for in Article 156, which grants the judge the authority to designate the professional responsible for preparing the technical report.

The new CPC also strengthened the principle of cooperation and expanded the role of the parties in the production of expert evidence, allowing them to appoint technical assistants and present questions to the expert (§ 1, Art. 465). Additionally, Article 473 requires the expert report to explicitly present the methods employed, the theoretical foundations, and the documents supporting the conclusions, thereby reinforcing the need for a technically qualified and transparent performance.

The 2015 procedural reform represents a milestone in the enhancement of forensic accounting, as the requirement for explicit methodology and technical justification within expert reports imposes on experts the obligation to act with scientific rigor. This includes the use of statistical techniques, financial projections, and quantitative analyses, particularly in cases involving estimations of losses, lost profits, or material damages.

The new procedural framework therefore establishes a higher quality standard for expert work, which must meet both legal requirements and technical criteria of methodological consistency. The absence of mathematical justification or the use of arbitrary assumptions can compromise the validity of the report and, consequently, its evidentiary effectiveness.

2.3 Legal Foundations of Lost Profits

The concept of lost profits (*lucro cessante*) is legally established in Brazilian law through Article 402 of the Civil Code, which defines it as a component of losses and damages, alongside direct damages (*dano emergente*). According to this provision, "unless otherwise expressly provided by law, losses and damages owed to the creditor include both what they effectively lost and what they reasonably failed to gain" (Brasil, 2002). Lost profits therefore correspond to the income or gain that the injured party failed to obtain as a consequence of an unlawful act, contractual breach, or harmful event, making it essential to demonstrate both its plausibility and causal nexus.

From a forensic accounting perspective, the quantification of lost profits requires technical methods capable of estimating the economic–financial behavior of the injured party in the hypothetical absence of the damaging event. Wakim and Wakim (2012) emphasize that the measurement of lost profits must follow criteria of reasonableness and scientific grounding, using projections supported by historical data, comparable information, and suitable econometric methods.

In procedural terms, the 2015 Code of Civil Procedure grants a prominent role to expert evidence in the assessment of lost profits, especially in situations requiring specialized technical knowledge. Article 464 states that expert evidence must be employed when the verification of facts depends on scientific knowledge, and that the expert must act with impartiality and objectivity (Brasil, 2015).

To ensure full compensation for damages, forensic accounting must consider not only nominal estimated values but also monetary correction and the application of statutory interest, as established by Constitutional Amendment No. 113/2021, which instituted the Selic rate as the index for updating judicial debts owed by the government (Brasil, 2021). The proper application of these parameters confers legitimacy to forensic calculations and aligns expert work with the principles of full reparation and legal certainty.

2.4 The Enhancement of Expert Evidence Through Quantitative Methods

The growing demand for judicial decisions grounded in empirical data and technical evidence has encouraged the incorporation of quantitative methods into the construction of expert evidence. These methods include statistical analyses, historical time-series modeling, discounted cash flow evaluations, financial projections, and various econometric techniques. In the context of forensic accounting, the application of such methodological tools significantly strengthens the conclusions presented in expert reports, conferring greater legitimacy, transparency, and reliability to judicial decisions based on technical evidence.

Quantitative models are particularly relevant in cases involving the calculation of lost profits, as they allow for the simulation of economic–financial performance that would reasonably be expected in the absence of the damaging event. For such simulations to have legal and technical validity, they must be grounded in realistic assumptions, verifiable data, and methodologically recognized models.

In this regard, the evolution of quantitative methods applied to forensic accounting has consolidated econometrics as a robust and reliable tool for measuring damages, lost profits, and other economic–financial variables. Although Ordinary Least Squares (OLS) is widely used in cross-sectional and panel data analyses (Wooldridge, 2013), its direct application to time-series data requires caution due to the risks of spurious regressions and non-stationarity (Enders, 2014; Stock & Watson, 2019). For this reason, models specifically designed for time-series data, such as SARIMA, tend to offer more consistent methodological results for forecasting purposes. Such modeling plays a strategic role in expert examinations, especially in contexts requiring technical quantification of economic effects arising from business interruption, loss of contracts, or productivity reductions.

According to Sengupta (2021), advancements in econometrics have substantially improved the understanding of economic and financial phenomena, expanding its practical applicability and usefulness in complex decision-making environments. The author emphasizes that econometrics is a dynamic field, continually evolving, and contributes decisively to making the decision-making process more robust and evidence-based.

OLS, as described by Gujarati and Porter (2011), is grounded in seven essential assumptions that ensure the statistical validity of its estimators: (1) linearity in parameters; (2) random sampling and absence of measurement error; (3) no perfect multicollinearity; (4) zero conditional mean of errors; (5) homoscedasticity; (6) no serial correlation; and (7) normality of residuals, especially important for inference. Compliance with these assumptions grants estimators the properties of unbiasedness, efficiency, and consistency, which are fundamental in forensic contexts.

It is important to note that although OLS can be used in certain situations after adequate data treatment, its application to time-series data without addressing temporal dependence may lead to erroneous or spurious results (Enders, 2014). Even adjustments such as Newey–West robust standard errors correct only the inference and do not solve model misspecification (Stock & Watson, 2019). Practically, analysts may apply logarithmic transformations to stabilize variance or include deterministic terms and seasonal dummies to control periodic patterns. When violations such as heteroskedasticity or autocorrelation persist, inference must employ HAC-consistent standard errors to ensure validity.

Despite these limitations, OLS may still be useful in specific empirical contexts, but time-series models such as ARIMA, SARIMA, or ETS are generally more appropriate when the primary objective is forecasting or estimating lost profits, given their ability to capture temporal dependence, seasonality, and stochastic shocks.

Thus, applied econometrics emerges as a valuable instrument in the construction of technical evidence in judicial proceedings, especially in light of the requirement for objective and scientifically grounded justification of expert conclusions. As highlighted by Lee, Chen, and Lee (2019), econometric methods have proven particularly effective in financial analysis, planning, and forecasting, generating information relevant for decision-making based on both historical data and statistical inference.

Consequently, the use of econometric models in forensic accounting meets the requirements established by the 2015 Code of Civil Procedure regarding the explicit presentation of methods, technical foundations, and coherence between data and conclusions (Brasil, 2015, Art. 473). This reinforces the role of forensic accounting as a legitimate, technical, and scientifically grounded evidentiary mechanism within the Brazilian judicial system.

2.5 Use of the IPCA-E in the Adjustment of Fiscal Debts

The *Índice de Preços ao Consumidor Amplo Especial* (IPCA-E — Special Extended Consumer Price Index) is widely used in the legal sphere as an instrument for adjusting fiscal debts. In this regard, the Court of Justice of the Federal District and Territories (2024) states:

> 1. Following the final judgment of RE 870.947/SE (DJe 11/20/2017), Article 1-F of Law 9.494/1997 was declared unconstitutional insofar as it regulated the monetary adjustment of amounts owed by the Public Treasury according to the official remuneration of savings accounts (Referential Rate – TR), as it imposed a disproportionate restriction on the right to property.
> 2. In light of the understanding set forth by the Federal Supreme Court, with general repercussion, the monetary correction of judgments against the Public Treasury must be calculated using the *Índice de Preços ao Consumidor Amplo Especial* (IPCA-E), regardless of the existence of a precatório.
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> Judgment No. 1.297.781, Case 07270578220208070000, Reporting Judge: Eustáquio de Castro, Eighth Civil Panel, judgment on 10/29/2020, published in DJe on 11/13/2020.

Silva (2024) reinforces the use of the IPCA-E as the index for adjusting fiscal debts prior to Constitutional Amendment No. 113/2021:

> In replacing the correction mechanism linked to savings accounts, both RE 870.947/SE and ADI 5.348/DF established the IPCA-E as the index for correcting debts owed by the Public Treasury, emphasizing that 'in the judgment of Direct Actions of Unconstitutionality Nos. 4.357 and 4.425, the Court determined that, after 03/25/2015, all credits registered as precatórios must be adjusted by the IPCA-E. In this exact sense, I vote for the application of this index to all judicial condemnations imposed on the Public Treasury, regardless of the federative entity involved.

In a special appeal judged by the Court of Justice of the State of Minas Gerais, the following considerations were presented:

> 1. Monetary correction: Article 1-F of Law 9.494/97 (as amended by Law 11.960/2009), for the purpose of monetary correction, is not applicable to judicial condemnations imposed on the Public Treasury, regardless of their nature. 1.1 Impossibility of aprioristic determination of the monetary correction rate: In the present judgment, the establishment of indices to be applied as monetary correction does not entail a predetermined or aprioristic definition of a correction rate. Instead, the decision is based on indices that currently reflect monetary adjustment for the corresponding period. In this context, for future situations, the application of the indices in question, particularly **the INPC and the IPCA-E is legitimate as long as these indices remain capable of capturing the inflationary phenomenon**. *(emphasis added)*

Finally, Constitutional Amendment No. 113 of 2021 establishes the Selic rate as the mechanism for adjusting debts involving the Public Treasury (Brasil, 2021):

> Art. 3. In disputes and condemnations involving the Public Treasury, regardless of their nature and for the purposes of monetary adjustment, capital remuneration, and default compensation—including precatórios—the *taxa Selic* (Selic rate), accrued monthly, shall be applied once, until full payment.e.

2.7 Selected Related Studies

Nohýnková (2022) structures the measurement of lost profits by comparing the counterfactual (revenues and costs that would have occurred in the absence of the damaging event) with the factual scenario (observed revenues and costs), formalizing the loss as the difference between counterfactual profit and actual profit. Alternatively, the author presents the formulation "lost revenues – avoided costs," which is particularly useful when there is limited knowledge about the cost structure.

She also systematizes classical projection methods (Before-and-After, Yardstick/Comparable, and But-for) and identifies Discounted Cash Flow (DCF) as the reference approach for bringing projected cash flows to present value, while emphasizing the importance of distinguishing *actual damages* from *lost profits* when categorizing economic items.

In the Brazilian context, the study by Costa, Mença, and Postiglione (2024) highlights forensic accounting as a technical–scientific instrument for pursuing material truth, governed by specific accounting standards (NBC TP 01 and NBC PP 01) that regulate planning, procedures, and the preparation of the expert report, in addition to setting the competencies required of forensic experts. The authors review the regulatory evolution within the Federal Accounting Council (CFC) (Resolutions 1.243/2009 and 1.244/2009) and reinforce that forensic procedures (examination, inspection, valuation etc.) must support verifiable conclusions capable of assisting judicial decision-making.

Oliveira Filho et al. (2025), in turn, analyze 203 judgments from the Business Courts of São Paulo and identify a low use of forensic accounting for determining lost profits, despite the technical–accounting complexity of the matter. Among the 113 cases that reached the liquidation phase, 90 involved no expert examination whatsoever; of the 23 cases with expert evidence, only 10 included an accounting expert. These findings suggest a misalignment between forensic theory and judicial practice, with potential implications for the accuracy of damage calculations.

From a time-series perspective, several recent studies have demonstrated the applicability of this technique in forensic accounting and in the measurement of financial variables. Internationally, Medwin Publishers (2020) emphasize that time-series analysis can be used in forensic accounting to detect anomalies, support fraud investigations, and produce more consistent estimates in expert proceedings, underscoring the role of these models as evidentiary tools. Complementarily, Nigrini (2011) shows how time-series methods allow comparisons between observed values and expected projections, facilitating the identification of significant deviations that may indicate irregularities or asset losses.

In the Brazilian literature, researchers have also explored the statistical properties of financial series. An example is the study by Martinez (2009), who examined the characteristics of quarterly profit time series of Brazilian firms, confirming the presence of autocorrelation and persistent patterns in accounting data. Such evidence reinforces the need for models capable of handling serial dependence and non-stationarity.

More recent contributions include Granger et al. (2025), who analyzed the forecasting of financial indicators such as revenues, costs, and profits using classical time-series techniques and comparing them with other forecasting methods. The authors concluded that Box–Jenkins-based models still provide strong predictive performance in business environments. This conclusion directly aligns with the proposed application of SARIMA for the measurement of lost profits, given that business revenues typically exhibit seasonality and structural shocks.

Finally, new trends have been incorporated into forensic accounting. Singh and Verma (2023) discuss the use of artificial intelligence in forensic auditing, noting that machine learning techniques can be integrated with time-series models to improve real-time detection of fraud and financial losses. This development signals a convergence between traditional statistical methods and AI-based approaches, opening new avenues for future research in the field of forensic accounting.

3 METHODOLOGY

The study adopts a quantitative approach grounded in time-series techniques applied to the measurement of lost profits. Initially, the use of the Classical Linear Regression Model (OLS) was considered; however, this strategy proved inadequate given the typical characteristics of revenue time series, such as non-stationarity, serial autocorrelation, and the presence of seasonality. For this reason, the SARIMA model

(Seasonal Autoregressive Integrated Moving Average) was selected, as it is widely recognized in the literature (Box & Jenkins, 1976; Greene, 2012; Gujarati & Porter, 2011) as more suitable for time-dependent data.

It is important to emphasize that although OLS was initially considered, stationarity tests and residual diagnostics demonstrated the inadequacy of this model, leading to the adoption of SARIMA, which is more appropriate for the statistical properties of revenue series.

3.1 Structuring the Database

For illustrative purposes, a time series representing a company's monthly revenue over 240 periods (20 years) was simulated. The values were constrained between R$ 15,000.00 and R$ 30,000.00 to replicate plausible market oscillations, including a growth trend, annual seasonality, and random shocks. The choice of simulation reflects the methodological nature of the study, which does not aim to reproduce real cases, but rather to demonstrate the applicability of the forensic procedure. As a limitation, it is noted that real series may present structural breaks, exogenous shocks, and greater heterogeneity, requiring additional adjustments.

3.2 Stationarity Tests

The first step of the analysis consisted of assessing the stationarity of the series using the Augmented Dickey-Fuller (ADF) test. This statistical test evaluates the null hypothesis of a unit root, whose rejection indicates that the series is stationary. The results showed that revenue was not stationary at level, requiring the application of both regular and seasonal differencing to ensure stability of the mean and variance over time.

3.3 Model Structure Identification

After differencing, correlograms of the Autocorrelation Function (ACF) and the Partial Autocorrelation Function (PACF) were inspected to identify potential orders of the autoregressive (p, P) and moving average (q, Q) components. These graphical tools indicated short-term dependence and an annual seasonal pattern, guiding the initial specification of a SARIMA (1,1,1)(0,1,1) model.

3.4 SARIMA Modeling

The SARIMA model was estimated using the Maximum Likelihood method implemented in Stata 17. Model adequacy was assessed using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC), prioritizing parsimony and predictive capacity. Additionally, the stability of the autoregressive and moving-average roots was verified to ensure stationarity and invertibility conditions.

3.5 Residual Diagnostics

The estimated residuals were examined for serial autocorrelation using the Ljung-Box test (*wntestq*), whose null hypothesis states the absence of autocorrelation. Failure to reject the null confirmed that the residuals behaved as white noise, indicating proper model specification. The residuals were also inspected for a mean close to zero, constant variance, and an approximately normal distribution—fundamental requirements for valid inference.

3.6 Forecasting Future Values

Once validated, the model was used to forecast revenue over a 60-month horizon, generating both point estimates and 95% confidence intervals. Forecasts were produced on the variable's original scale, preserving economic interpretability. These projected values were subsequently employed to estimate lost profits, adjusted according to current legal parameters using the PROJEF Web system.

3.7 Monetary Adjustment and Interest

The estimated lost profits were subjected to monetary correction and the application of statutory interest in accordance with current legislation:

- Until November 2021: adjustment using the IPCA-E and default interest of 1% per month, as consolidated in Brazilian jurisprudence;
- From December 2021 onwards: application of the accumulated Selic rate, pursuant to Constitutional Amendment No. 113/2021.

All calculations were performed using the PROJEF Web system, the official platform of the Federal Court of the 4th Region, ensuring compliance with applicable legal and jurisprudential standards.

4 RESULTS AND DISCUSSIONS

4.1 Descriptive Statistics of the Simulated Variable

Initially, the variables *revenue* and *time* were created in Stata, forming the basis for the simulation of lost profits using time-series techniques with the addition of seasonality to the initially estimated values. The results of this procedure are presented in Table 1, which displays the main statistics derived from this process.

Table 1
Descriptive Statistics of the Simulated Revenue Variable

Variable	*Obs.*	*Mean*	*Standart Deviation*	*Minimum*	*Maximum*
Revenue	240	US$ 4,697.18	US$ 434.26	US$ 3,630.34	US$ 5,514.70

Source: Prepared by the author based on the simulation
Note: Values converted to US dollars. R$ 5.44 = US$ 1.00

Table 1 summarizes the descriptive statistics of the company's revenue series, composed of 240 observations, corresponding to approximately 20 years of monthly data. The average revenue was US$ 4,697.18, a value positioned in the upper third of the observed range (US$ 3,630.34 to US$ 5,514.70). This indicates that the company maintained performance close to the upper boundary of its revenue-generating capacity throughout the analyzed period.

The calculated standard deviation was US$ 434.26, representing roughly 9.2% of the mean, which reveals moderate variability: the series is not excessively volatile, yet it displays fluctuations that may be attributable to seasonal factors or market shocks.

The minimum recorded value (US$ 3,630.34) corresponds to a drop of approximately 22.7% relative to the mean, suggesting periods of more pronounced revenue contraction. Conversely, the maximum value (US$ 5,514.70) aligns with the upper limit of the defined interval, indicating the presence of truncation in the data distribution. This characteristic may produce slight negative skewness, as values tend to concentrate near the ceiling while displaying greater dispersion near the lower bound.

Overall, the relative stability of the series—expressed by a coefficient of variation of about 9% demonstrates favorable conditions for applying forecasting models based on time series, such as SARIMA or Holt-Winters. These models are capable of capturing the long-term trend and seasonal patterns present in the data, thereby enhancing the robustness of projections. Nevertheless, the truncation at the maximum value should be taken into account in subsequent analyses, as it may introduce bias if the upper threshold does not reflect a natural limitation of the firm's revenue-generating process.

4.2 Econometric Modeling of the Simulated Variable for Lost-Profit Estimation

The analysis of the revenue series followed a structured sequence of methodological procedures aimed at identifying the most appropriate time-series model to represent the dynamics of the data and enable robust forecasting. Initially, the temporal database was constructed, consisting of 240 monthly observations. This step included the chronological organization of the variable and the formal declaration of the time-series structure in Stata using the *tsset* command, which allows the use of specialized tools for time-series analysis.

In the subsequent stage, the stationarity of the series was examined an essential condition for the application of ARIMA/SARIMA models. For this purpose, the Augmented Dickey-Fuller (ADF) test was applied, using up to 12 lags and including a deterministic trend. The objective was to evaluate the null hypothesis of a unit root. If stationarity were not confirmed, the series would be transformed through simple differencing (to remove trend) and/or seasonal differencing of order 12 (to eliminate recurring annual patterns), resulting in transformed variables (*D.revenue* and *D12.revenue*).

The test results showed that the revenue variable was not stationary in levels. Consequently, differencing became essential in order to satisfy the statistical requirements necessary for time-series modeling.

Next, the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) were analyzed. These correlograms allowed inspection of short- and long-term serial dependence and also indicated the possible presence of seasonality through significant spikes at multiples of 12 lags. The joint interpretation of the ACF and PACF plots guided the preliminary selection of the orders for the autoregressive (AR), moving-average (MA), and seasonal components (P, D, Q) (FIGURES 1 and 2).

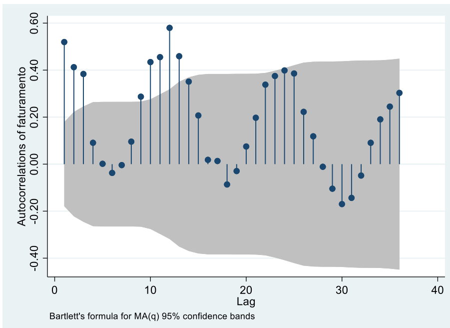

Figure 1. Revenue AC

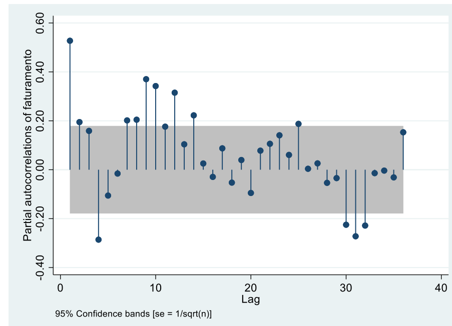

Figure 2. Revenue PAC

Source: Prepared by the author based on the simulation.

Based on this evidence, a SARIMA(1,1,1)(0,1,1)[12] model was specified and estimated. The model incorporates one autoregressive term and one moving-average term in the non-seasonal component, along with annual seasonal differencing and a seasonal moving-average component. Estimation was carried out using the maximum likelihood method implemented in Stata's *arima* command. Model adequacy was assessed using the Akaike Information Criterion (AIC) and the Schwarz Bayesian Information Criterion (BIC), prioritizing parsimony, as well as through the inspection of characteristic roots (*estat aroots*), ensuring stationarity and invertibility conditions.

The validation stage included an examination of the residuals from the fitted model, obtained using the *predict, resid* command. Autocorrelation tests particularly the Ljung-Box test, were then applied to evaluate whether the residuals behaved as white noise. The absence of serial autocorrelation in the residuals, combined with a mean close to zero and constant variance, confirmed the adequacy of the estimated model (p-value = 0.5997).

These procedures from stationarity tests, through ACF/PACF inspection, to estimation and validation of the SARIMA model constituted the basis for selecting the final specification. Once validated, the SARIMA(1,1,1)(0,1,1)[12] model was used to generate level forecasts for the revenue variable over a 60-month horizon, incorporating trend, seasonality, and stochastic shocks, as shown in Figure 3.

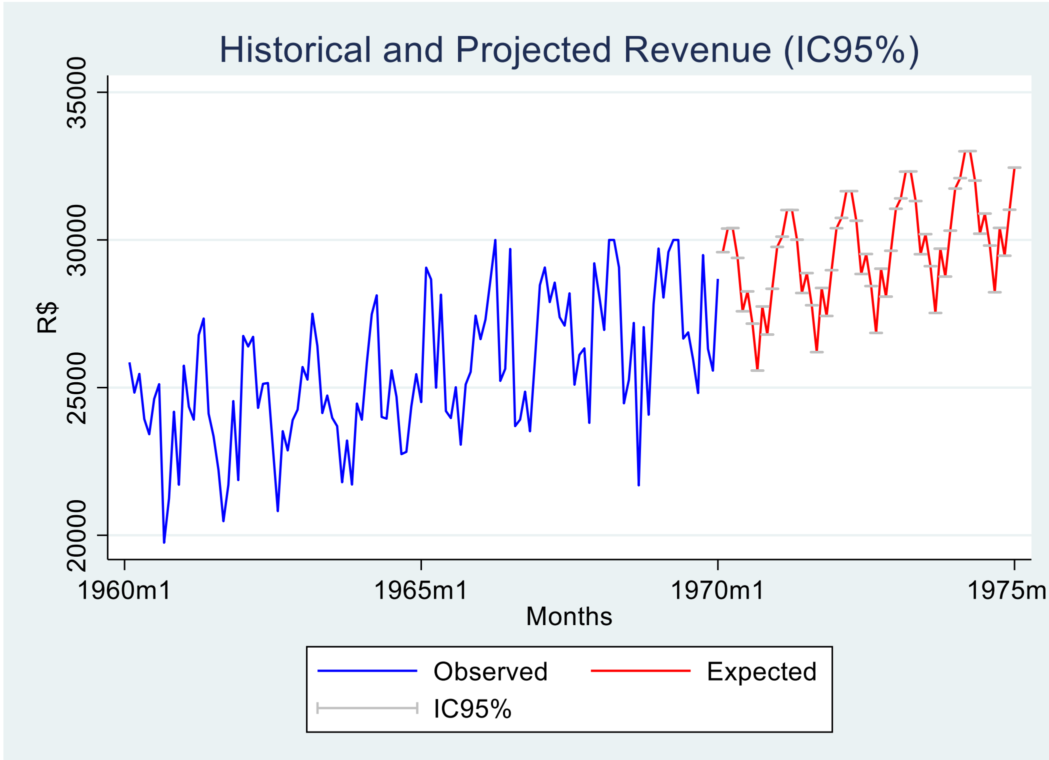

Figure 3. Revenue Forecast for the Next Five Years
Source: Prepared by the author based on the simulation performed
Note: Estimation routine provided at the end

Table 2 presents the results of the SARIMA model forecast, which enabled the estimation of the lost-profit values to be subsequently subjected to monetary adjustment and the application of statutory interest through the PROJEF Web system.

Table 2
Lost-Profit Projection for a 60-Month Period

Time	Estimated Revenue	Time	Estimated Revenue	Time	Estimated Revenue
1	US$ 5.439,60	21	US$ 5.216,82	41	US$ 5.426,86
2	US$ 5.586,52	22	US$ 5.042,47	42	US$ 5.551,72
3	US$ 5.589,90	23	US$ 5.327,61	43	US$ 5.352,32
4	US$ 5.403,83	24	US$ 5.588,69	44	US$ 5.061,20
5	US$ 5.071,81	25	US$ 5.652,84	45	US$ 5.461,35
6	US$ 5.195,48	26	US$ 5.819,01	46	US$ 5.287,78
7	US$ 4.994,92	27	US$ 5.819,84	47	US$ 5.573,70
8	US$ 4.702,62	28	US$ 5.635,16	48	US$ 5.835,56
9	US$ 5.101,60	29	US$ 5.303,81	49	US$ 5.900,49
10	US$ 4.926,86	30	US$ 5.428,28	50	US$ 6.067,45
11	US$ 5.211,60	31	US$ 5.228,50	51	US$ 6.069,06
12	US$ 5.472,29	32	US$ 4.936,99	52	US$ 5.885,15
13	US$ 5.536,05	33	US$ 5.336,74	53	US$ 5.554,59
14	US$ 5.701,83	34	US$ 5.162,78	54	US$ 5.679,84

15	US$ 5.702,27	35	US$ 5.448,31	55	US$ 5.480,84
16	US$ 5.517,19	36	US$ 5.709,78	56	US$ 5.190,11
17	US$ 5.185,46	37	US$ 5.774,33	57	US$ 5.590,64
18	US$ 5.309,54	38	US$ 5.940,88	58	US$ 5.417,47
19	US$ 5.109,36	39	US$ 5.942,10	59	US$ 5.703,77
20	US$ 4.817,46	40	US$ 5.757,81	60	US$ 5.966,02
			Total Estimated Revenue		**US$ 327,704.87**

Source: Prepared by the author based on the simulation of Revenue
Note: Values converted to US dollars. R$ 5.44 = US$ 1.00

After estimating the amount corresponding to lost profits, it was necessary to subject the values to monetary adjustment in order to preserve the real value of the obligation over time. To this end, monthly monetary correction was applied to the projected values, together with the incidence of default interest at the rate of 1% per month, as established by Brazilian civil procedural legislation.

To ensure technical rigor and adherence to the parameters used by the Judiciary, the PROJEF Web system made available by the Federal Court of the 4th Region (Rio Grande do Sul), was selected as the official tool for calculating monetary correction and statutory interest. This choice ensures the standardization of adjustment criteria and methodological conformity with the parameters adopted in judicial decisions, resulting in the economically updated value of the lost profits.

For the monetary adjustment and application of default interest to the values estimated as lost profits, the PROJEF Web system was used, adopting criteria compatible with current legal parameters. In the "Monetary Adjustment" tab, the IPCA-E index was selected as the correction index. Additionally, the option to apply the Selic rate from December 2021 onward was activated, in accordance with Constitutional Amendment No. 113/2021, which redefined the rules governing the adjustment of judicial debts owed by the Public Treasury. The update date for the calculations was set to the latest available in the system June 2025.

In the "Default Interest" tab, the annual rate of 12% (equivalent to 1% per month) was selected, consistent with the practice consolidated in Brazilian jurisprudence for obligations not subject to a specific contractual rate. To determine the starting point for the calculation of interest, the date of service of process was used as the reference, since this is the procedural moment at which the defendant is formally notified of the lawsuit, thereby establishing the procedural legal relationship between the parties and the court. For illustrative purposes, August 2021 (08/2021) was adopted as the initial date.

In the "Parties and Installments" tab, all monthly lost-profit installments previously estimated through the time-series model were entered so that the system could automatically perform the adjustment calculations. For illustrative purposes, the "Name" field was filled with the description *Lost Profits*, and the "CPF" field was assigned a randomly generated number solely to enable the system's functionality. The values to be updated were copied directly from a Microsoft Excel spreadsheet and pasted into the system.

Finally, in the “Final Data” tab, all mandatory fields were completed, and the calculation command was executed. The result obtained through this procedure is consolidated in Table 3.

Table 3
Lost Profits Duly Updated Using the PROJEF Web System

Lost Profit	Data	Principal (A)	Monetary Adjustment Coefficient (B)	Corrected Principal (C=AxB)	Interest (%) until 12/21 (D)	Interest Principal (E=CxD)	Selic% from 12/21 (F)	Selic$ (G=(C+E)xF)	Total(R$) (H=C+E+G)
1	jan/20	5,439.60	1.14201	6,212.08	23.00%	1,428.78	43.89%	3,353.57	10,994.43
2	fev/20	5,586.52	1.133959	6,334.89	22.00%	1,393,67	43.89%	3,392.07	11,120.63
3	mar/20	5,589.90	1.13147	6,324.80	21.00%	1,328.21	43.89%	3,358.90	11,011.91
4	abr/20	5,403.83	1.131243	6,113.04	20.00%	1,222,61	43.89%	3,219.62	10,555.27
5	mai/20	5,071.81	1.131357	5,738.03	19.00%	1,090.23	43.89%	2,996.92	9,825.17
6	jun/20	5,195.48	1.138071	5,912.83	18.00%	1,064,31	43.89%	3,062.26	10,039.40
7	jul/20	4,994.92	1.137844	5,683.43	17.00%	966.18	43.89%	2,918.52	9,568.13
8	ago/20	4,702.62	1.13444	5,334.84	16,00%	853.58	43.89%	2,716.10	8,904,52
9	set/20	5,101.60	1.131837	5,774.17	15.00%	866.13	43.89%	2,914.43	9,554.73
10	out/20	4,926.86	1.126767	5,551.42	14.00%	777.20	43,89%	2,777.63	9,106.24
11	nov/20	5,211.60	1.116274	5,817.57	13.00%	756.28	43.89%	2,885.27	9,459.12
12	dez/20	5,472.29	1.107304	6,059.49	12.00%	727.14	43.89%	2,978.65	9,765.27
13	jan/21	5,536.05	1.09569	6,065.80	11.00%	667.24	43.89%	2,955.13	9,688.17
14	fev/21	5,701.83	1.08721	6,199.09	10.00%	619.91	43.89%	2,992.86	9,811.85
15	mar/21	5,702.27	1.082016	6,169.95	9.00%	555.30	43.89%	2,951.71	9,676.96
16	abr/21	5,517.19	1.072046	5,914.69	8.00%	473.17	43.89%	2,803.63	9,191.49
17	mai/21	5,185.46	1.065652	5,525.90	7.00%	386.81	43.89%	2,595.09	8,507.80
18	jun/21	5,309.54	1.060984	5,633.34	6.00%	338.00	43.89%	2,620.82	8,592.16
19	jul/21	5,109.36	1.05225	5,376.33	5.00%	268.82	43.89%	2,477.65	8,122.80
20	ago/21	4,817.46	1.044728	5,032.94	4.00%	201.32	43.89%	2,297.31	7,531.57
21	set/21	5,216.82	1.035512	5,402.08	3.00%	162.06	43.89%	2,442.10	8,006.25
22	out/21	5,042.47	1.02384	5,162.69	2.00%	103.25	43.89%	2,311.22	7,577.17
23	nov/21	5,327.61	1.0117	5,389.94	1.00%	53.90	43.89%	2,389.30	7,833.14

24	dez/21	5,588.69	1.0000	5,588.69	0.00%	0.00	43.89%	2,452.88	8,041.56
25	jan/22	5,652.84	1.0000	5,652.84	0.00%	0.00	43.12%	2,437.51	8,090.35
26	fev/22	5,819.01	1.0000	5,819.01	0.00%	0.00	42.39%	2,466.68	8,28569
27	mar/22	5,819.84	1.0000	5,819.84	0.00%	0.00	41.63%	2,422.80	8,242.65
28	abr/22	5,635.16	1.0000	5,635.16	0.00%	0.00	40.70%	2,293.51	7,928.67
29	mai/22	5,303.81	1.0000	5,303.81	0.00%	0.00	39.87%	2,114.63	7,418.44
30	jun/22	5,428.28	1.0000	5,428.28	0.00%	0.00	38.84%	2,108.35	7,536.63
31	jul/22	5,228.50	1.0000	5,228.50	0.00%	0.00	37.82%	1,977.42	7,205.91
32	ago/22	4,936.99	1.0000	4,936.99	0.00%	0.00	36.79%	1,816.32	6,753.30
33	set/22	5,336.74	1.0000	5,336.74	0.00%	0.00	35.62%	1,900.95	7,237.69
34	out/22	5,162.78	1.0000	5,162.78	0.00%	0.00	34.55%	1,783.74	6,946.52
35	nov/22	5,448.31	1.0000	5,448.31	0.00%	0.00	33.53%	1,826.82	7,275.13
36	dez/22	5,709.78	1.0000	5,709.78	0.00%	0.00	32.51%	1,856.25	7,566.02
37	jan/23	5,774.33	1.0000	5,774.33	0.00%	0.00	31.39%	1,812.56	7,586.89
38	fev/23	5,940.88	1.0000	5,940.88	0.00%	0.00	30.27%	1,798.31	7,739.19
39	mar/23	5,942.10	1.0000	5,942.10	0.00%	0.00	29.35%	1,744.01	7,686.11
40	abr/23	5,757.81	1.0000	5,757.81	0.00%	0.00	28.18%	1,622.55	7,380.36
41	mai/23	5,426.86	1.0000	5,426.86	0.00%	0.00	27.26%	1,479.36	6,906.22
42	jun/23	5,551.72	1.0000	5,551.72	0.00%	0.00	26,14%	1,451.22	7,002.94
43	jul/23	5,352.32	1.0000	5,352.32	0.00%	0.00	25.07%	1,341.83	6,694.15
44	ago/23	5,061.20	1.0000	5,061.20	0.00%	0.00	24.00%	1,214.69	6,275.89
45	set/23	5,461.35	1.0000	5,461.35	0.00%	0.00	22.86%	1,248.46	6,709.81
46	out/23	5,287.78	1.0000	5,287.78	0.00%	0.00	21.89%	1,157.49	6,445.28
47	nov/23	5,573.70	1.0000	5,573.70	0.00%	0.00	20.89%	1,164.35	6,738.04
48	dez/23	5,835.56	1.0000	5,835.56	0.00%	0.00	19.97%	1,165.36	7,000.92
49	jan/24	5,900.49	1.0000	5,900.49	0.00%	0.00	19.08%	1,125.81	7,026.31
50	fev/24	6,067.45	1.0000	6,067.45	0.00%	0.00	18.11%	1,098.81	7,166.26

51	mar/24	6,069.06	1.0000	6,069.06	0.00%	0.00	17.31%	1,050.55	7,119.61
52	abr/24	5,885.15	1.0000	5,885.15	0.00%	0.00	16.48%	969.87	6,855.02
53	mai/24	5,554.59	1.0000	5,554.59	0.00%	0.00	15.59%	865.96	6,420.55
54	jun/24	5,679.84	1.0000	5,679.84	0.00%	0.00	14.76%	838.35	6,518.19
55	jul/24	5,480.84	1.0000	5,480.84	0.00%	0.00	13.97%	765.67	6,246.51
56	ago/24	5,190.11	1.0000	5,190.11	0.00%	0.00	13.06%	677.83	5,867.94
57	set/24	5,590.64	1.0000	5,590.64	0.00%	0.00	12.19%	681.50	6,272.14
58	out/24	5,417.47	1.0000	5,417.47	0.00%	0.00	11.35%	614.88	6,032.35
59	nov/24	5,703.77	1.0000	5,703.77	0.00%	0.00	10.42%	594.33	6,298.11
60	dez/24	5,966.02	1.0000	5,966.02	0.00%	0.00	9.63%	574.53	6,540.55
Totais		**US$ 327,704.79**		**US$ 339,271.10**		**US$ 16,304.09**		**US$ 119,926.89**	**US$ 475,502.07**

Summary Table

Name	Corrected Principal	Default interest	Selic	Total (US$)
Lost Profit	US$ 327,704.79	US$ 339,271.10	US$ 119,926.89	US$ 475,502.07
		TOTAL	**US$ 475,502.07**	

Table 4 presents, in a detailed manner, the steps processed by the PROJEF Web system related to the monetary updating of the estimated lost profits obtained through the application of the Seasonal Time Series Model (SARIMA). In the summary panel generated by the system, it is observed that the initially projected amount was updated to a corrected principal of US$ 327,704.79. To this amount, default interest was added, totaling US$ 339,271.10. Additionally, monetary adjustment calculated based on the Selic rate resulted in an increment of US$ 119,926.89. Thus, the final value of the lost profits, duly corrected and updated, reached a total of US$ 475,502.07.

5 FINAL CONSIDERATIONS

The present study demonstrated the applicability of time series modeling specifically the SARIMA model in the measurement of lost profits within forensic accounting. By projecting revenue behavior in a counterfactual horizon, the method proved capable of incorporating trend, seasonality, and random shocks, thereby producing grounded estimates that are statistically verifiable. This result reinforces the relevance of applied econometrics as a technical support tool for expert analyses, enhancing objectivity and transparency in the quantification of economic damages.

Nonetheless, certain limitations must be acknowledged. First, the data employed in this study were simulated for didactic and illustrative purposes, which does not fully capture the complexity inherent to real-world revenue series. Moreover, although the observation window was adequate for methodological demonstration, a longer historical period could increase the robustness of the estimates. It is also important to recognize that, in practical contexts, financial series are subject to structural breaks, sectoral volatility, and exogenous shocks such as those evidenced during the Covid-19 pandemic which may require additional adjustments to the proposed models.

It should also be highlighted that the Classical Linear Regression Model (OLS), initially considered, proved inadequate due to non-stationarity, serial autocorrelation, and pronounced seasonality in the revenue data. The adoption of the SARIMA model allowed overcoming these limitations, in accordance with recommendations in the financial time series literature.

In light of these findings, future research is encouraged to advance in three directions: (i) the application of the methodology to real empirical datasets from firms to validate its practical suitability; (ii) comparative analysis of predictive performance across different models, such as Holt–Winters, VAR, and machine learning algorithms; and (iii) the incorporation of exogenous variables including macroeconomic indicators and sectoral índices which may enrich counterfactual estimates.

Therefore, although the present exercise presents inherent limitations, the use of time series modeling represents a more consistent methodological alternative than OLS for the assessment of lost profits, strengthening forensic accounting evidence and contributing to judicial decisions that are more equitable and technically grounded.

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APPENDIX (SIMULATION ROUTINE)

```
*****************************************************

REVENUE SIMULATION WITH SEASONALITY AND FORECASTING

*****************************************************
```

```
clear all
set more off

*------------------------------------------------------
* 1. Criar base simulada (20 anos = 240 meses)
*------------------------------------------------------
set obs 240
gen t = _n
gen mes = mod(t,12)
replace mes = 12 if mes==0

* Base média
gen base = 22500

* Tendência linear
gen tendencia = 50*t

* Componente sazonal (ciclo anual)
gen sazonal = 2000*sin(2*_pi*t/12) + 1000*cos(2*_pi*t/12)

* Ruído aleatório
set seed 12345
gen ruido = rnormal(0,1500)

* Faturamento final
gen faturamento = base + tendencia + sazonal + ruido
replace faturamento = max(faturamento,15000)
replace faturamento = min(faturamento,30000)

* Declarar série temporal mensal
tsset t, monthly

* Visualizar série
tsline faturamento,  title("Faturamento mensal simulado") xtitle("Meses")
ytitle("R$")
*------------------------------------------------------
* 2. Testes preliminares
*------------------------------------------------------
dfuller faturamento, lags(12) trend

*------------------------------------------------------
* 3. Identificação (ACF e PACF)
*------------------------------------------------------
ac faturamento, lags(36) name(ac_raw, replace)
pac faturamento, lags(36) name(pac_raw, replace)
```

```
*--------------------------------------------------
* 4. Ajuste de modelo SARIMA inicial
*--------------------------------------------------
arima faturamento, arima(1,1,1) sarima(0,1,1,12)

* Critérios de informação
estat ic

* Diagnóstico de resíduos
predict ehat, resid
wntestq ehat, lags(12)    // Teste de Ljung-Box

*--------------------------------------------------
* 5. Projeção de faturamento para 60 meses à frente
*--------------------------------------------------
tsappend, add(60)

* Previsão em nível da variável 'faturamento'
predict faturamento_prev, dynamic(121) y

* Erro-padrão da PREVISÃO (forecast std error)
predict faturamento_prev_se, stdf

* Intervalo de confiança 95%
gen faturamento_prev_lo = faturamento_prev - 1.96*faturamento_prev_se
gen faturamento_prev_hi = faturamento_prev + 1.96*faturamento_prev_se

*--------------------------------------------------
* 6. Visualizar previsão
*--------------------------------------------------
twoway ///
 (tsline faturamento if t<=120, lcolor(blue)) (line faturamento_prev t if t>=121,
lcolor(red)) (rcap faturamento_prev_hi faturamento_prev_lo t if t>=121,
lcolor(gs12)), title("Histórico e Projeção do Faturamento (IC95%)")
legend(order(1 "Observado" 2 "Previsto" 3 "IC95%")) xtitle("Meses") ytitle("R$")

*--------------------------------------------------
* 7. Sumarizar projeção (60 meses)
*--------------------------------------------------
quietly summarize faturamento_prev if t>=121
display "Soma prevista de faturamento (60 meses): R$ " %15.2f r(sum)

****************************************************
* END OF SCRIPT
****************************************************
```