



# Modeling and simulation of the operational risk of fiduciary institutions in Colombia

## Modelaje y simulación del riesgo operativo de las instituciones fiduciarias en Colombia

**Mg. Fausto Camilo Vahos-Zuleta** is a full-time professor at CEIPA University Foundation (fausto.vahos@ceipa.edu.co) (<https://orcid.org/0000-0002-2180-5831>)

**Mg. David Alberto Bedoya-Londoño** is a full-time professor at the Faculty of Engineering at the University of Medellín. Researcher of the Research Group in Financial Engineering-GINIF- of the University of Medellín (dabedoya@udem.edu.co) (<https://orcid.org/0000-0001-8453-8075>)

**Mg. Antonio Boada** is a full-time professor at CEIPA University Foundation. Belongs to the Orygen and IMCA research group (Colombia) (antonio.boada@ceipa.edu.co) (<https://orcid.org/0000-0002-8882-768>)

### Abstract

*Through this work, a model was developed that has become the first experience to measure and forecast the impact that net losses have had on operating risk in fiduciary companies in Colombia and that would allow fiduciary companies to study and analyze the evolution and impact that operating risk has on their profits. The financial services industry sector has been exposed to a number of risks that lead to losses in these entities, and in the financial system in general; thus, through the definition of operational risk and operational risk management, the study of risk indicators is implemented through the EaR (Risk Usability) methodology, established in three phases: on the one hand, the selection and compilation of the financial information of the fiduciaries to be studied; the determination of the financial statements, with the construction of the income statement, and ending with the determination of the probabilistic distribution that adapts to the historical information, to then determine the correlations between the determined accounts, in order to be able to establish the EaR through Monte Carlo simulations. In this way, it was possible not only to build a model to quantify operating risk, based on financial information on income and expenses, but also to obtain relevant statistical information on the impact of operating risk.*

### Resumen

Mediante este trabajo se desarrolló un modelo que se ha convertido en la primera experiencia para medir y estimar el impacto que han tenido las pérdidas netas en el riesgo operativo en las fiduciarias en Colombia y que permitiera a las fiduciarias estudiar y analizar la evolución y el impacto que tiene el riesgo operativo en sus utilidades. El sector de la industria de servicios financieros se ha visto expuesto a una cantidad de riesgos que conllevan a pérdidas en dichas entidades, y al sistema financiero en general; es así cómo a través de la definición de riesgo operativo, y la gestión de riesgo operacional, se implementa el estudio de indicadores de riesgo a través de la metodología EaR (Utilidad de riesgo), establecido en tres fases: por un lado, la elección y recopilación de la información financiera de las fiduciarias a estudiar; la determinación de los estados financieros, con la construcción del estado de resultados, y finalizando con la determinación de la distribución probabilística que se adapta a la información histórica, para luego determinar las correlaciones entre las cuentas determinadas, para poder establecer el EaR a través de simulaciones de montecarlo. De esta manera, se ha podido no solo construir un modelo de cuantificación del riesgo operativo, a partir de la información financiera de ingresos y gastos, sino también obtener información estadística relevante sobre el impacto del riesgo operativo.

### Keywords | palabras clave

*Operational risk, trust companies, EaR, profits and losses.*  
Riesgo operativo, fiduciarias, EaR, utilidades y pérdidas.

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## 1. Introducción

Any organization regardless of the economic sector (industrial, services, or financial) is exposed to countless events that can affect its objectives and impede them from reaching the financial goals initially set. All of these situations, which are difficult to predict, are known as risks.

Due to the development of the financial services industry in the world, this sector has been increasingly exposed to a number of risks that entail losses for the entities themselves and the financial system in general. Among the most common risks are market risks, credit risks, liquidity risks, and operational risk could not be ignored; which, according to the survey of members of the British Bank Association, 67 % indicated that operational risk is much more significant than credit and market risks. In this same vein, operational risk has been considered by the Basel Committee as the risk that has caused the most losses to the financial system in the world (Basel, 2004). Likewise, (Yao et al., 2013, p. 16) indicate that an investigation carried out by the World Bank has shown that one of the most frequent causes for bankruptcy of the banking industry in the world has been operational risk.

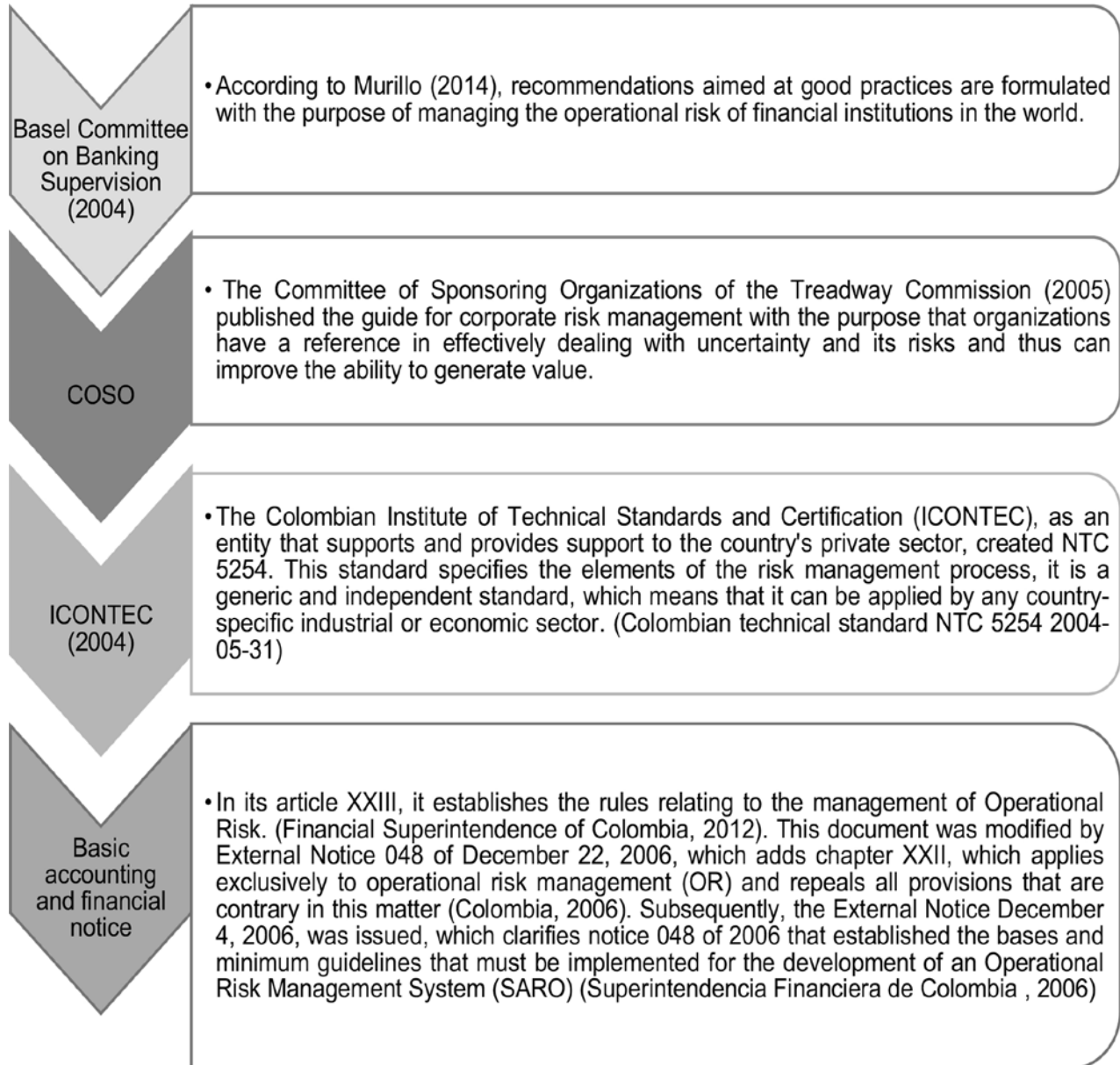
The operational risk, according to the Financial Superintendency of Colombia (2007) corresponds to “the possibility of incurring losses due to deficiencies, failures or inadequacies in human resources, processes, technology, infrastructure or due to the occurrence of external events”; including the legal and reputational risk associated with such factors. In this order of ideas, (Pinto & Leyva-Lemarie, 2008, p. 98), point out that the types of operational risks are the consequence of four conditions:

- People: internal fraud, employment practices, and job security.
- Processes: execution, delivery, and management of projects and/or clients, products, and commercial practices.
- Systems: interruption of operations or system failures.
- External: damage or loss of physical assets and/or external fraud.

In the particular case of Colombian banking entities, they recognize that operational risk management exceeds the simple requirement of supervisory authorities and becomes an opportunity to achieve organizational objectives and add value to the services they provide. According to Pinto (Pinto & Leyva-Lemarie, 2008), this opportunity also contributes to improving each of the processes of these institutions. Having made the above considerations, it is convenient to highlight the importance of trust entities in Colombia, since they have significant participation in the national financial industry. In the annual report published by the Colombian Financial Superintendency in 2018, the Colombian financial system reached a total asset level of \$ 1715 billion, which is equivalent to approximately 1.8 times the Colombian GDP, of which \$ 659 billion, that is, 38 % corresponds to credit institutions and in second place are Trust Companies with \$ 529 billion, which means 31 % of the total Financial System (Asociación de Fiduciarias de Colombia, 2019).

Next, in Figure 1, the standards developed in Colombia and internationally that are the benchmarks for managing operational risk in fiduciary institutions are described.

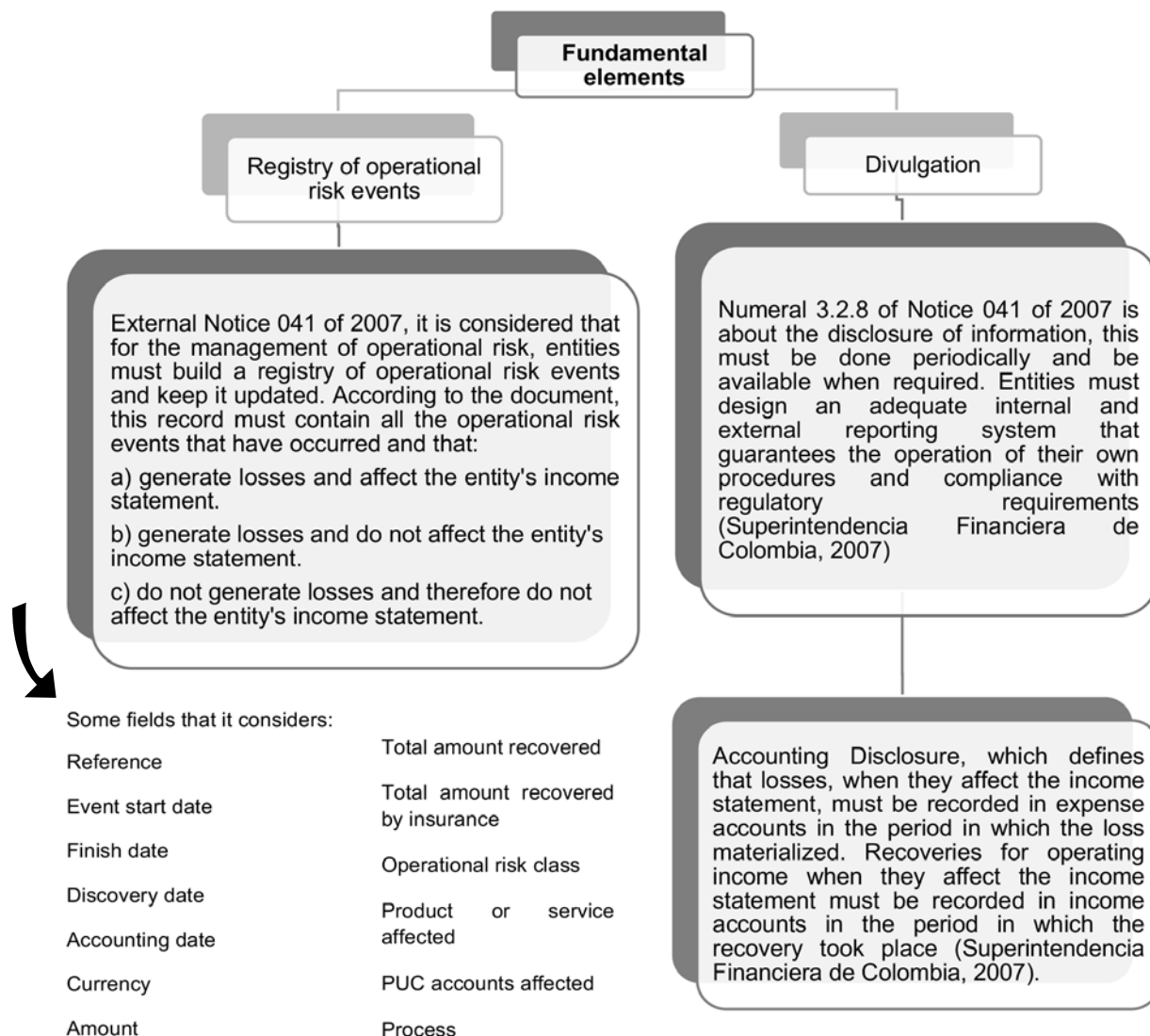
**Figure 1. Standards developed to perform operational risk management**



Source: Own elaboration

Any entity that is subject to the inspection and oversight of the Financial Superintendency of Colombia (SFC) must develop a SARO that allows them to effectively identify, measure, control, and monitor operational risk through elements such as policies, procedures, documentation, organizational structure, and even the registry of operational risk events (Superintendencia Financiera de Colombia, 2007). Thus, for the research carried out, two fundamental elements were taken into account, which are presented in Figure 2.

Figure 2. Fundamental elements to consider



Source: Own elaboration

After the above, it should be noted that there are different methodologies for quantifying operational risk in fiduciaries. These include the following:

- Value at Risk VaR:** according to (Triana et al., 2018, p. 174) it is a “statistical technique that allows to measure and quantify the exposure to market risk, defining the maximum potential loss that an asset can suffer or a portfolio of assets for a period of time and a certain level of confidence”.
- The Loss Distribution Approach (LDA) method:** according to (Macías-Villalba et al., 2018, p. 13) “It is a statistical technique that aims to determine the distribution function of aggregate losses. This model is built on the information of recorded historical losses and has its origin in applications in the insurance industry”.
- The Bayesian Networks:** (Dávila-Aragón & Ortiz-Arango, 2019, p. 34) comments that “Bayesian models are models of causality, which indicates that it is a man-

agement instrument used to predict the different courses of action and intervention. In these models, the cause-and-effect relationship is maintained between the different variables of the OR to reduce it, manage it and control it". It is important to mention that these models not only focus on quantifying it, but it is also essential to understand the causes of OR and the way in which loss events are reached.

In the same order and direction (Dávila-Aragón & Ortiz-Arango, 2019, p.33) indicate that:

Bayesian networks are a viable alternative for risk analysis under insufficient information conditions and incorporate information through a priori probability distribution, which makes it possible to incorporate subjective data in decision-making and expert opinions and analysts' judgment.

For his part, (Holder Bonin, 2007, p. 928), establishes that:

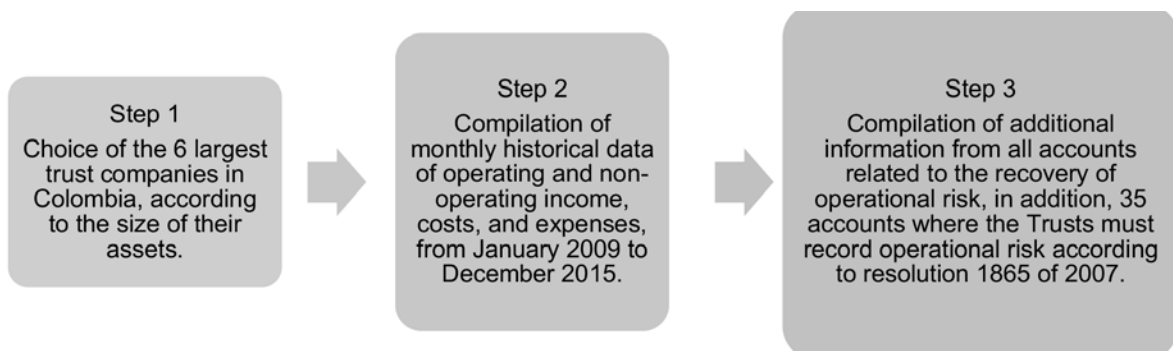
... The EaR methodology measures the amount of earnings at risk and the net income that could change, as well as the VaR, also this measurement is considered a risk measure and is closely linked to the calculated value of the maximum risk loss in a horizon time and under a certain level of confidence. The difference is that while VaR analyzes the change in the total value in the period considered. EaR looks at possible changes in cash flows or earnings.

## 2. Methodology

According to the Association of Fiduciaries of Colombia and the Financial Superintendence of Colombia (SFC), Colombia has 23,809 trust businesses, of which, according to the assets managed as of the date of this study, six main ones stand out, representing more than 50 % of total assets (Asofiduciarías, 2019) (Castilla, 2019). This is how, to carry out the study, the choice of the following Trusts was considered: Fiduciaria Bancolombia S.A, Previsora S.A, Bogotá S.A, Fiduoccidente S.A, Fiduskandia S.A, and Fiduciaria Davivienda; applying the study in three phases, which are presented in the following figure:

**Figure 3. Phase I of the methodology: Selection and collection of information**

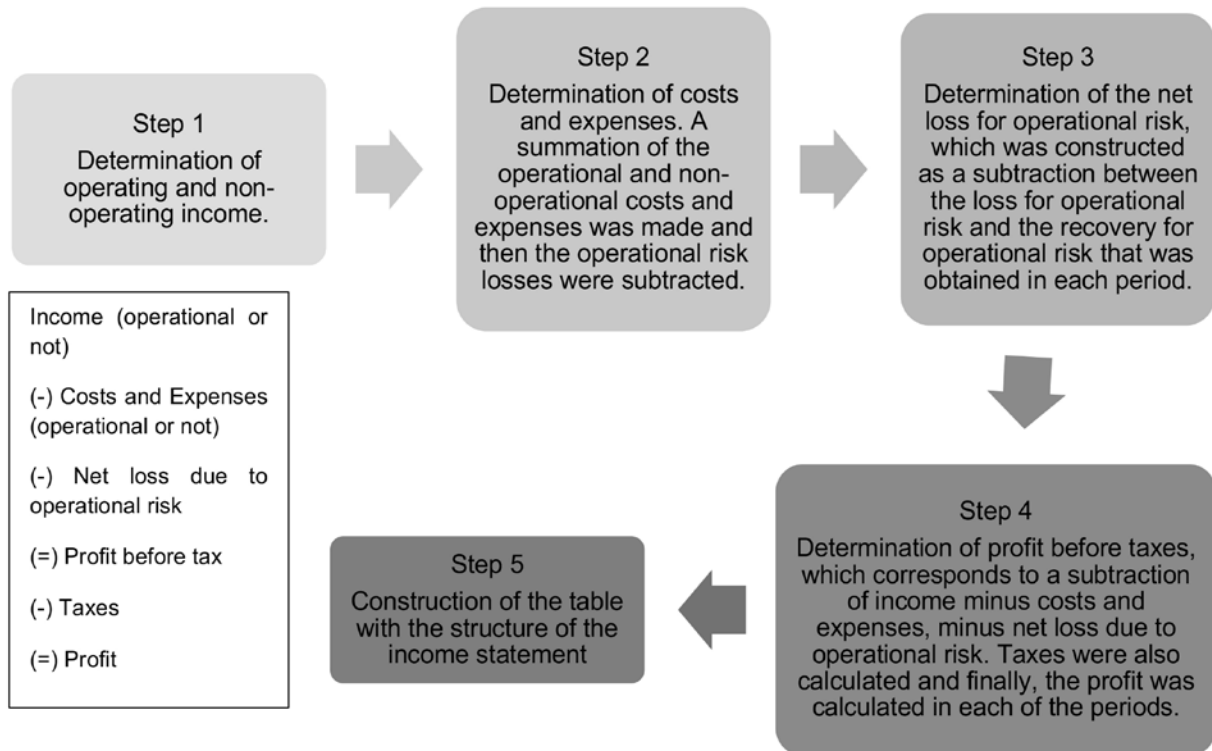
Phase I:



Source: Own elaboration

**Figure 4. Phase II of the methodology: Determination of the income statement**

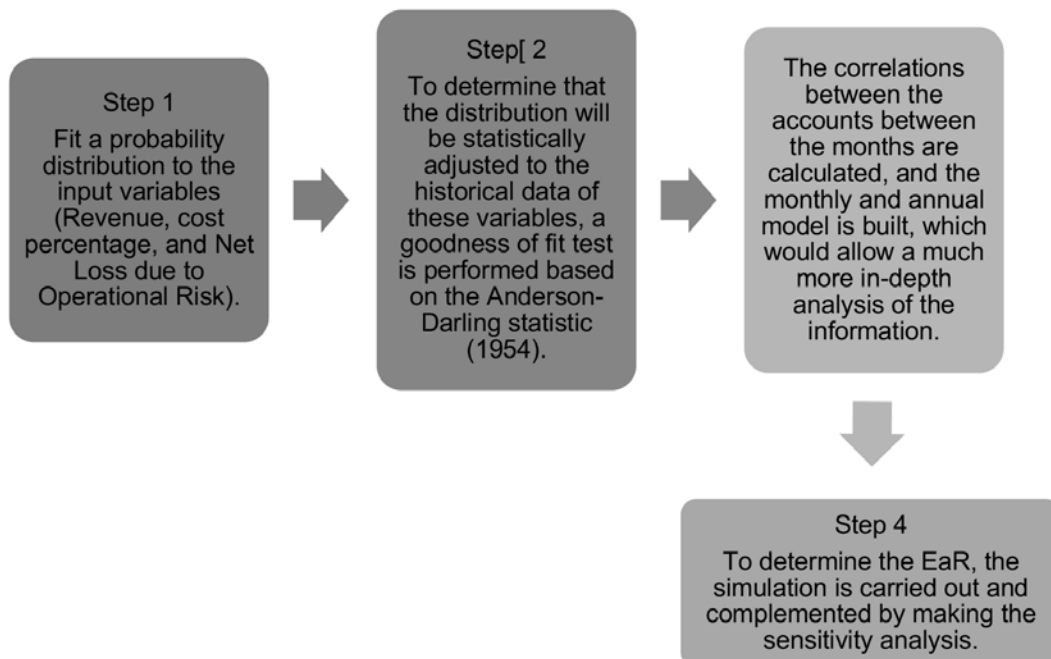
Phase II:



Source: Own elaboration

**Figure 5. Phase III of the methodology: Probability Distribution and Monte Carlo Simulation**

Phase III:



Source: Own elaboration

### 3. Results

#### 3.1. Results of net losses due to operational risk in relation to income and gross profit

Table 1 shows the net operating risk losses, expressed in thousands of pesos. The net loss obtained by each trust company between the years 2009-2015 are linked together, extracted from the public information of the Financial Superintendence of Colombia (SFC, 2019) and the general average is calculated for each of the years. The red color indicates that said loss was above the general average obtained in that year and the green color indicates that said loss was below the general average in that year.

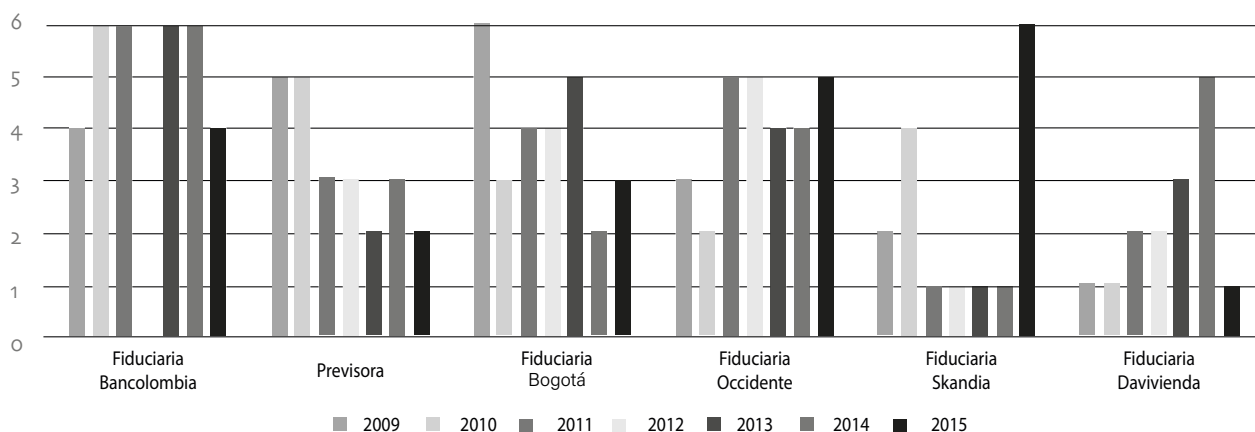
**Table 1. Annual Account: Net losses due to operational risk (Values in dollars)**

	2009	2010	2011	2012	2013	2014	2015
Fiduciaria Bancolombia	1 115 363,81	853 781,31	1 325 474,61	1 651 038,19	1 683 615,99	6 123 025,00	918 042,99
Previsora	2 436 958,68	548 629,72	117 149,60	752 757,32	251 944,72	272 394,67	126 548,49
Fiduciaria Bogotá	69 798 506,14	385 539,28	217 362,57	794 774,83	800 316,07	241 349,28	181 398,53
Fiduciaria Occidente	496 553,52	281 904,96	771 278,45	897 949,22	485 235,03	391 083,03	930 909,28
Fiduciaria Skandia	88 237,70	424 923,75	-219 854,64	81 538,99	-6173,62	69 948,63	1 149 615,19
Fiduciaria Davivienda	959,00	44 880,27	31 939,81	116 631,49	283 501,04	621 780,97	110 913,95
Average	12 322 763,14	423 276,55	373 891,73	715 781,67	583 073,21	1 286 596,93	569 571,41

Source: Own elaboration, extracted from the public data of the Financial Superintendency of Colombia.

Figure 6 shows a ranking of the net operating risk loss of the trust companies.

**Figure 6. Fiduciary operational risk net loss hierarchy**



A score of 6 is an indicator of the maximum net loss due to operational risk, a score of 1 is an indicator of the minimum net loss due to operational risk.

Source: Own elaboration

In Figure 6 a ranking of the net loss due to the operational risk of the trusts is made. With 6 being the maximum net loss due to operational risk and 1 being the lowest net loss due to operational risk of the 6. In the case of Bancolombia's fiduciary, in 2009 it obtained the 4th highest loss, but between 2010 and 2014 it was the fiduciary that had the highest loss due to operational risk, occupying the 6th position.

From the values present in the table and the behavior seen in figure 6, it can be highlighted that:

- a) The fiduciary Bancolombia for six years had a net loss for operating risk above the average, only in 2009 it was below the average. This trust obtained the largest loss of the six companies analyzed for five consecutive years (2010 to 2014) since it obtained a score of 6. Taking into account the above situation, one might think that the Bancolombia trust is the riskiest, but there are It must be borne in mind that this company is the largest of all, if it is analyzed from the point of view of assets. The previous analysis establishes the need to create indicators that allow for deeper analysis and especially allow for aggregate analysis since the differences in size of the trust companies in Colombia would prevent reaching much more forceful conclusions.
- b) Davivienda fiduciary presented a loss for operational risk below the general average of all years, which shows that it is the best in the management of operational risk. Additionally, in Figure 6, the ranking of the operational risk of this company shows that in 2009 and 2010 it was the one with the lowest loss due to operational risk and is growing in an ascending manner until it becomes the second with the highest loss due to operational risk among the six companies analyzed.
- c) The Skandia fiduciary, for four consecutive years, presented operating risk losses below the average; even in 2010, said loss exceeded the average, but for a very small value (\$ 1,647 million). Only in 2015, it obtained a significant net loss for operational risk and much higher than the average, which was \$ 1,149,615.

On the other hand, table 2 shows the relationship between the net losses due to operational risk and the income of the six analyzed companies. This information is important since it allows quantifying the impact that operational risk losses have on the income of the six main trust companies in Colombia.

**Table 2. Net operating risk losses/Income**

	2009	2010	2011	2012	2013	2014	2015
Fiduciaria Bancolombia	0,56 %	0,45 %	0,62 %	0,70 %	0,75 %	2,61 %	0,35 %
Previsora	2,10 %	0,45 %	0,08 %	0,42 %	0,12 %	0,14 %	0,06 %
Fiduciaria Bogotá	34,03 %	0,32 %	0,17 %	0,55 %	0,55 %	0,15 %	0,10 %
Fiduciaria Occidente	0,77 %	0,43 %	1,14 %	1,10 %	0,59 %	0,44 %	1,02 %
Fiduciaria Skandia	0,77 %	2,06 %	-1,94 %	0,92 %	-0,02 %	0,20 %	2,70 %
Fiduciaria Davivienda	0,00 %	0,15 %	0,10 %	0,18 %	0,36 %	0,69 %	0,12 %
Average	6,37 %	0,64 %	0,03 %	0,65 %	0,39 %	0,70 %	0,73 %

Source: Own elaboration



In order to correctly interpret the data of each one of the companies analyzed during the seven years, the following case is explained: for Previsora in 2009, it showed a value of 2.10 % which indicates that for each peso of income, 2.10 cents of loss for operational risk were obtained. Taking into account the previous explanation, the following can be said in general terms:

- a) The impact that the loss of operational risk had on the income of all trust companies is not high, since the percentage was mostly below 1 %.
- b) The most significant event was presented with the Bogota trust company in 2009, where the great impact of the millionaire embezzlement case suffered by this financial entity is evidenced. For each peso that it obtained in income, the Bogotá company presented an operating risk loss of 34.03 cents. This shows that unexpected events of this magnitude significantly affect trust companies.
- c) In 2010 and 2014, five of the six trust companies obtained an operating risk loss in relation to the income below the average in those years.
- d) The Occidente fiduciary experienced an operating risk loss above the average for four years, which indicates that it is the most affected trust in income from losses related to operating risk.
- e) Davivienda fiduciary is the company where its income has been least affected since six of the seven analyzed years said indicator was below the average; adding that in 2009 this indicator was 0%.
- f) It is important to mention the evolution of the net losses due to operational risk in relation to the income of the Previsora trust company, where it is possible to observe a decrease in recent years in relation to 2009, which is very positive for said company. The opposite case has been experienced by Davivienda, given that for four consecutive years this loss was increasing and only decreased in the last year of the analysis.

Additionally, Table 3 shows the relationship between the net losses due to operational risk and the profit of the six analyzed fiduciaries. This information is important since it allows quantifying the impact that operational risk losses have on the profit of the six main trust companies in Colombia.

**Table 3. Net Loss due to Operational Risk/Net Income**

	2009	2010	2011	2012	2013	2014	2015
Fiduciaria Bancolombia	1,31 %	1,16 %	1,67 %	2,02 %	2,86 %	10,23 %	0,99 %
Previsora	8,37 %	1,63 %	0,29 %	1,43 %	0,47 %	0,75 %	0,42 %
Fiduciaria Bogotá	192,17 %	0,90 %	0,45 %	1,37 %	1,53 %	0,41 %	0,27 %
Fiduciaria Occidente	1,93 %	0,99 %	2,72 %	2,74 %	1,60 %	1,22 %	2,58 %
Fiduciaria Skandia	1,38 %	2,95 %	-4,90 %	14,98 %	-0,02 %	0,37 %	4,78 %
Fiduciaria Davivienda	0,01 %	0,30 %	0,21 %	0,43 %	1,34 %	2,66 %	0,42 %
Average	34,19 %	1,32 %	0,07 %	3,83 %	1,30 %	2,61 %	1,58 %

Source: Own elaboration

To correctly interpret the data of each of the fiduciaries in the seven analyzed years, the following case is explained: for the Skandia Fiduciary in 2009 it presented a value of 1.38% which indicates that for each peso of net profit obtained by this fiduciary, had 1.38 cents of loss for operational risk. In the case of the Previsora fiduciary, the loss in relation to profit was below the average in relation to the other analyzed fiduciaries.

#### 4. Calculation of EaR

The Anderson-Darling (1954) goodness-of-fit test was used to determine the probability distribution that best adjusted to each of the variables selected for the model (income, percentage of costs, and net loss due to exploitation risk). When some of the variables did not fit the theoretical distributions, they fit the empirical distribution, that is, a distribution that uses the same data to predict their future behavior. This distribution was built with the help of the @Risk software and is called the RiskGeneral function.

For the construction of the RiskGeneral function, the minimum value, the maximum value, the class, and the frequency of the historical data of the variable are required. This is obtained from the data analysis tool, frequency histogram, offered by Microsoft Excel. The results are presented in Table 4:

**Table 4. Probability distribution according to the variable**

Variable Fiduciary	Income	% of costs	Net loss from operational risks
Bancolombia	Logistic	Normal	RiskGeneral
Previsora	Rayleigh	Pert	RiskGeneral
Bogotá	Loglogistic	Laplace	RiskGeneral
Occidente	RiskGeneral	RiskGeneral	RiskGeneral
Skandia	RiskGeneral	Cauchy	RiskGeneral
Davivienda	RiskGeneral	RiskGeneral	RiskGeneral

Source: Own elaboration

Once the probability distributions for each variable have been defined, we proceed to build the monthly and annual Monte Carlo simulation model. Before indicating the results of the monthly simulation, the following terms must be defined:

- a. Income: is the random number generated taking into account the distribution adjusted to the historical income data that depends on the correlation between the accounts.
- b. Expenses: it is obtained from the multiplication between the income with the random number generated by the distribution adjusted to the % of historical expense that depends on the correlation between the accounts.
- c. Loss due to operational risk: it is a random number generated by the adjusted distribution of the historical net loss that depends on the correlation between the accounts.
- d. Profit before taxes: these are income minus expenses minus the net loss due to operational risk.

- e. Taxes: % of taxes is the result of the historical average of the entity for the profit before taxes.
- f. Profit: It is the difference between profit before taxes and taxes. This is considered the output variable of the model.

For the monthly simulation model, the correlation matrix between the income accounts, % of costs and expenses, and net loss due to operational risk are calculated to consider the effect of the relationships with the analyzed concepts, and the simulation model is built as detailed in table 5.

**Table 5. Monthly simulation model**

Income statement per month (thousands)	Month
Income	7 290 511 679
Expenses	6 569 686 027
Net loss due to operational risk	6 706 050
Profit before tax	714 119 602
Tax	160 056 478
Profit	554 063 124

Source: Own elaboration

The annual simulation model was built to determine the net losses of operational risk projected for the next year and thus be able to analyze its effect on the profits of the main trust companies in Colombia (Boada, 2016; 2000).

Before indicating the results of the annual simulation, the following terms must be defined:

- a) Income: it is obtained by adding the monthly income and at the same time they are random numbers generated by the distribution adjusted to the historical income data that depends on the correlation between the values of the months of the income.
- b) Expenses: is the sum of the monthly expenses that are calculated as the multiplication between the income with the random number generated by the distribution adjusted to the historical % of expenses that includes the correlation between the values of the months of the % of expense.
- c) Loss due to operational risk: it is the sum of the monthly net losses that are a random number generated by the distribution adjusted to the data of the historical net loss that depends on the correlation between the values of the months of the net losses due to operational risk. Additionally, it is an output variable of the simulation model.
- d) Profit before tax: income minus expenses minus net loss due to operational risk.
- e) Tax: % of tax determined as the historical average of the entity by the profit before tax

- f) Profit: is the difference between profit before tax and the tax accounting field. It is the output variable of the model.

For the annual simulation model, it is detailed in table 6.

**Table 6. Annual simulation model**

Income statement per month (thousands)	Month 1	...	Month 12	Total anual
Income	1 136 376 631	...	2 008 240 701	24 276 929 765
Expenses	993 380 209	...	1 990 081 292	20 863 725 938
Net loss due to operational risk	6 291 486	...	7 562 810	94 544 463
Profit before tax	136 704 936	...	10 596 599	3 318 659 364
Tax	30 639 840	...	2 375 028	761 358 364
Profit	106 065 096	...	8 221 571	2 557 301 000

Source: Own elaboration

Subsequently, 10,000 iterations are carried out in order to project the profits and net losses due to operational risk for the next period and thus be able to calculate the EaR. These results can be seen in table 7.

**Table 7. Results of the Monte Carlo Fiduciary simulation  
(data in thousands of pesos)**

Monthly simulation - profit	Statistical	Fiduciaria Bancolombia	Fiduciaria Bogotá	Fiduciaria Davivienda	Fiduciaria Occidente	Fiduciaria Previsora	Fiduciaria Skandia
	Mean	6 172 231	1 414 195	1 399 294	1 853 008	3 269 932	383 154
	Deviation	1 465 692	2 439 069	856 552	1 977 233	1 706.255	998 729
	Minimum	1 667 545	-6 261 563	-4 889 273	-1 244 429	-451 879	-2 290 680
	Maximum	13 430 891	168 368 182	5 080 686	10 202 715	11 453 492	12 268 919
	P (Profit > 0)	100 %	100 %	98,64 %	100 %	99,94 %	100 %
	5% percentile	3 895 567	294 927	444 551	92.400	942.576	-438.923
	95% percentile	8 651 850	3.342.678	3 018 555	6 630 626	6 444 574	2 180 373
	EaR	2 276 664	1 119 268	954 743	1 760 608	2 327 355	822 077
Annual simulation by profit	Statistical	Fiduciaria Bancolombia	Fiduciaria Bogotá	Fiduciaria Davivienda	Fiduciaria Occidente	Fiduciaria Previsora	Fiduciaria Skandia
	Mean	74 348 111	15 374 774	19 060 003	18 769 632	38 720 471	2 208 622
	Deviation	5 881 965	8 124 479	11 215 543	6 790 635	14 747 746	2 980 780
	Minimum	50 407 468	1 560 494	-27 704 516	1 664 210	4 710 893	-13 468 835
	Maximum	97 439 202	234 492 625	63 319 898	55 536 072	126 514 241	29 281 400
	P (Profit > 0)	100 %	100 %	99,59 %	100 %	99,90 %	100 %
	5% percentile	64 826 070	8 893 163	5 513 253	10 092 975	18 283 094	-1 482 686
	95% percentile	84 260 990	27 195 695	40 174 498	31 759 286	65 886 988	7 774 180
	EaR	9 522 041	6 481 612	13 546 750	8 676 657	20 437 377	3 691 308

Monthly simulation - profit	Statistical	Fiduciaria Bancolombia	Fiduciaria Bogotá	Fiduciaria Davivienda	Fiduciaria Occidente	Fiduciaria Previsora	Fiduciaria Skandia
Annual simulation by profit	Statistical	Fiduciaria Bancolombia	Fiduciaria Bogotá	Fiduciaria Davivienda	Fiduciaria Occidente	Fiduciaria Previsora	Fiduciaria Skandia
	Mean	4 852 462	1 308 648	725 839	1 584 748	1 881 476	1 316 015
	Deviation	2 931 524	318 724	170 927	442 404	2 384 107	271 776
	Minimum	-12 965 405	374.347	43 263	504 631	-13 291 688	391 939
	Maximum	13 676 910	3 723 802	1 952 573	5 234.297	12 044.335	2 848 356
	P (Profit> 0)	93,76 %	100 %	100 %	100 %	60,53 %	100 %
	5% percentile	-811 522	970 497	506 700	1 049 374	-1 490 043	924 501
	95% percentile	9 028 892	1 897 913	1 061 698	2 387 062	6 047 108	1 830 758

Source: Own elaboration

In accordance with the previous results and considering table 7, the following is found:

- a) For the Bancolombia trust, the expected value of the profit is estimated at \$ 6172 million, which may decrease to \$ 3895 million with 95 % confidence; therefore, the maximum monthly profit loss for Bancolombia at 95 % confidence is EaR \$ 2,276 million. In annual terms, a profit of \$ 74,348 million is expected with an EaR \$ 9,522 million, although there is a 100 % probability that next year's profits will be greater than zero. On the other hand, the net losses due to operational risk for the next year are expected to have a value \$ 4852 million with a maximum probable loss at a confidence level of 95 % of \$ 9028 million, which is the value that must be provisioned for those events that directly affect the expense of the income statement.
- b) For the Bogotá fiduciary, the expected value of the profit for the next month is \$ 1,414 million, which can decrease to \$ 294 million with 95% confidence, therefore, the maximum loss of profit for the Bogotá fiduciary to a 95 % confidence is EaR \$ 1,119 million. In annual terms, a profit of \$ 15,374 million is expected with an EaR \$ 6,481 million, which is the value that the profits can fall from the value that is expected to be obtained, although there is a 100 % probability that the profits of next year will be greater than zero. On the other hand, the net losses due to operational risk for the next year are expected to have a value of \$ 1308 million with a maximum probable loss at a confidence level of 95% of \$ 1897 million, which is the value that must be provisioned for those events that directly affect the expense of the income statement.
- c) For the Davivienda trust company, the expected value of the profit for the next month is \$ 1,399 million, which may decrease to \$ 444 million with 95% confidence, therefore, the maximum profit loss for the Davivienda trust company at a 95% confidence is EaR \$ 9.54 million. In annual terms, a profit of \$ 19,060 million is expected with an EaR of \$ 13,546 million, which is the value that the profits can fall from the value that is expected to be obtained, although there is a probability of 99.59 % of the profits of next year being greater than zero. the net losses due to operational risk for the next year are expected to have a value of \$ 725 million with a maximum probable loss at a 95 % confidence level of \$

1061 million, which is the value that must be provisioned for those events that directly affect the expense of the income statement.

- d) For the Occidente fiduciary, the expected value of the profit for the next month is \$ 1853 million, which may decrease to \$ 92 million with 95 % confidence, therefore, the maximum loss of profit for the Occidente fiduciary at 95 % confidence is EaR \$ 1.76 billion. In annual terms, a profit of \$ 18,769 million is expected with an EaR \$ 8,676 million, which is the value that the profits can fall from the value that is expected to be obtained, although there is a 100 % probability that the profits of next year will be greater than zero. On the other hand, the net losses due to operational risk for the next year are expected to have a value of \$ 1,584 million with a maximum probable loss at a confidence level of 95 % of \$ 2,387 million, which is the value that must be provisioned for those events that directly affect the expense of the income statement.
- e) For the Previsora fiduciary, the expected value of the profit for the next month is \$ 3,269 million, which can decrease to \$ 942 million with 95% confidence, therefore, the maximum loss of profit for the Western fiduciary at a 95% confidence is EaR \$ 2.327 million. In annual terms, a profit of \$ 38,720 million is expected with an EaR of \$ 20,437 million, which is the value that the profits may fall from the value that is expected to be obtained, although there is a probability of 99.90% of the profits of the next year is greater than zero. On the other hand, the net losses due to operational risk for the next year are expected to have a value of \$ 1,881 million with a maximum probable loss at a confidence level of 95 % of \$ 6,047 million, which is the value that must be provisioned for those events that directly affect the expense of the income statement.
- f) For the Skandia fiduciary, the expected value of the profit for the next month is \$ 383,154 million, which can decrease to \$ 438,923 million with 95% confidence, therefore, the maximum loss of profit for the fiduciary of Skandia at 95% confidence is EaR \$ 822,077 million. In annual terms, a profit of \$ 2208 million is expected with an EaR \$ 3691 million, which is the value that the profits can fall from the value that is expected to be obtained, although there is a 100 % probability that the profits of next year will be greater than zero. On the other hand, On the other hand, the net losses due to operational risk for the next year are expected to have a value of \$ 1,881 million with a maximum probable loss at a confidence level of \$ 1,316 million with a maximum probable loss at a confidence level of 95 % of \$ 1,830 million, which is the value that must be provisioned for those events that directly affect the expense of the income statement.

## 5. Sensitivity analysis

Likewise, a sensitivity analysis was carried out, through the Tornado Analysis technique, used by the Risk Simulator software and documented in the document entitled: *Use of Risk Simulator® as a tool for valuation of comparable multiples. Case of companies in the Colombian electricity sector* (Boada, 2016), where it is possible to determine the level of variability of the model based on the fluctuation of the input variables, by + 10 %, which allowed quantifying the impact of net losses due to operational risk in the monthly profits of the six chosen fiduciaries.

Then, with this analysis, the correlation coefficient between the net loss due to operational risk and the profit was calculated, presented in Table 8 for the analyzed six fiduciaries.

**Table 8. Result of the Sensitivity Analysis for the Fiduciaries**

Fiduciary	Correlation coefficient
Bancolombia	-0,11
Bogotá	-0,11
Davivienda	0,23
Occidente	0,12
Previsora	-0,19
Skandia	0,13

Source: Own elaboration

For the case presented, the relationship between the net loss due to operational risk and the profit was small, which corroborates the historical analysis carried out; therefore, operational risk losses that affect the income statement do not have a significant effect on the companies' profits. While, on the other hand, the factors that most affected profits were the income and expenses of the companies.

Finally, it was observed that the fiduciaries Bancolombia, Bogotá, Previsora present negative correlation coefficients, with Previsora being the entity in which the loss for operational risk has a greater effect since it has a greater correlation coefficient -0.19 and Bancolombia and Bogotá are the fiduciary companies with a lower effect since their coefficients are -0.11 for both.

## 6. Conclusions and recommendations

The questions that we wanted to answer at the end of this article were: How could the Operational Risk losses of Trust institutions in Colombia be modeled based on the accounting disclosure requirement of the SARO? and how could the impact of Operational Risk be projected on the profits of Trust Institutions in Colombia?

The most significant result achieved in the research on the six largest fiduciaries in Colombia was the construction of a model that would allow the measurement and quantification of operational risk based on the financial information provided by the financial superintendency of Colombia on income, costs, and expenses and on net monthly operational risk losses during the period 2009-2015.

The construction of the Montecarlo simulation model allowed obtaining important statistical information on the impact that operational risk has on trust companies in Colombia. As a conclusion, it can be mentioned that, on average, the six trust companies had an expected value of the annual profit of \$ 27,397,864.55, with the Bancolombia trust the one that obtained an expected value greater than \$ 74,348,111.42. It is also important to mention that there is a high probability of obtaining a profit greater than 0 in the six analyzed fiduciaries.

The simulation made it possible to calculate the monthly and annual EaR for each of the analyzed fiduciaries. In annual terms, the trust with the highest maximum loss in profit was Previsora with \$ 20,437,377 and the one with the lowest maximum loss was Bogotá with a value of \$ 6,481,612. It is important to clarify that Bancolombia, being the largest of the sample was within the range with a maximum profit loss of \$ 9,522,041.

According to historical data obtained from the Financial Superintendency from 2009-2015, the impact of net losses due to operational risk ranges from 0.03 % to 0.73 % of companies' income. It is important to mention that this indicator increased significantly in 2009, reaching 6.37%, due to the event that occurred in the Bogota trust company. Additionally, the impact that net losses due to operational risk had on the profit of the trust companies had a similar movement, since it moved between 0.07 % and 3.83 %, making it once again clear that said indicator had an increase in 2009 significant going to 34.19 % in the case of the Bogota trust company.

For the Colombian case, this research becomes the first experience in calculating and measuring the impact that net losses on operational risk have had on trust companies in Colombia. Since there is evidence in other sectors such as the energy and banking sectors, but not in the Colombian trust companies, which may be the basis for carrying out this type of work with the same trust companies and even include others that were not taken into account by the criteria adopted in this work.

As a final recommendation, this type of simulation models and procedures, supported by computer programs, offer a perspective to analyze the behavior of a system in different circumstances and generate skills in a controlled environment (Uribe-Gómez & Quintero-Ramírez, 2017). This is interesting for trusts, and even supervisory authorities, in order to develop techniques, tools, strategies, and mechanisms that make it possible to assess operational risk losses and subsequently establish strategies to establish policies to reduce such potential losses.

It is important to indicate to the reader that this research was conducted in Colombia, taking into consideration the Colombian financial environment, dominated by the Colombian peso as the local currency. Likewise, the study reflects an exhaustive analysis carried out between 2009 and 2015, establishing a financial modeling proposal based on the numerical information collected from fiduciary institutions in Colombia, in order to establish the EaR (Risk Utility) through Monte Carlo simulations. In this way, given the scope of the study presented, the possibility of future work is to carry out comparative studies between the modeling and simulation carried out with the financial information presented as of 2020.

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